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13-25793

# Maine Agricultural Experiment Station

ORONO

BULLETIN 264

SEPTEMBER, 1917

## THE CURRANT FRUIT FLY

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## BULLETIN 264

# LIFE HISTORY, HABITS, NATURAL ENEMIES AND METHODS OF CONTROL OF THE CURRANT FRUIT FLY (*Epochra canadensis* Loew)<sup>1</sup>

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A number of naturalists have worked on the life history of the currant fruit fly (*Epochra canadensis* Loew) but the duration of all of the stages has never been determined. From a study of the life cycle of this insect, a number of scientists have suggested remedies for the control of this pest but most of these recommendations have not been previously put to a practical test. In our work we endeavored to determine the duration of all of the stages in the life history of the trypetid in the different fruits attacked under Maine conditions. Some of the different measures of control suggested by other workers were put to an experimental test, as well as other methods which we inaugurated. Observations were also made on the habits and behavior of the adults and on the natural enemies.

### SYSTEMATIC POSITION.

The currant fruit fly belongs to the order Diptera, or two-winged flies. This insect is a member of the family Trypetidae, a large group of flies usually possessing prettily marked wings. Loew (1873, p. 238) established the genus *Epochra* and gave it the specific name *canadensis* after Canada.

*Common name.*—In the literature, *Epochra canadensis* is known under various names as follows: *Currant fly*, *Currant fruit fly*, *Currant fruit miner*, *Currant fruit worm*, *Currant maggot*, *Currant or gooseberry fruit fly*, *Currant or gooseberry fruit maggot*, *Currant or gooseberry worm*, *Currant maggot or goose-fruit fly*, *Fruit maggot*, *Fruit worm*, *Gooseberry fruit fly*, *Yellow*

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currant fly, *Yellow currant fruit fly*, *Yellow currant fly or gooseberry fruit fly*, *Yellow currant and gooseberry fruit fly*.

The common name, currant fruit fly, has been adopted by the American Association of Economic Entomologists (1909, p. 15) and the pest should be so designated by writers in order that uniformity of common names of insects may be secured. This common name, however, is restrictive and misleading, as it naturally gives the impression that the fruit fly confines its attacks to currants; when, in reality, gooseberries are just as seriously infested. In all probability, the committee on nomenclature did not take into consideration the dark currant fly (*Rhagoletis ribicola* Doane) or a more distinctive common name would have been given to *Epochra canadensis*. The yellow currant or gooseberry fruit fly would have been a far more appropriate name for this trypetid.

#### DESCRIPTION OF ADULT.

*Epochra canadensis* is somewhat smaller than a house fly, and possess a more slender body. The body of recently emerged flies is pale yellow, but after the adults have been on the wing for a week or two the color changes to dark yellow. The legs are also yellow; the eyes are greenish iridescent and the wings are striped with brown crossbands (Fig. 17, A-E).

Harvey (1895, pp. 118-122) has published a technical description of the male and female fly, as well as of the egg, larva and pupa, and to these details those interested are referred.

#### DISTRIBUTION AND DESTRUCTIVENESS.

The distribution of the species in Canada and the United States was ascertained from literature and through correspondence with entomologists. A currant fruit fly was sent to nearly all Provincial entomologists, State entomologists and dipterologists accompanied with a letter asking for the locality record of any adults which might be found in their collections of insects or records from letters or notes. Records from letters when accompanied with infested currants or gooseberries or notes obtained from infested fruit observed in the field can not be considered reliable unless the imago is bred, for such fruit may have been attacked by the dark currant fruit fly (*Rhagoletis ribicola*

Doane) or possibly *Epochra rubida* Coq. if this is a distinct species.

North America is divisible into 7 transcontinental belts or life zones, each characterized by particular associations of animals and plants. These zones are: the Artic-Alpine, Hudsonian, Canadian, Transition, Upper Austral, Lower Austral and Tropical. The Transition zone is sub-divided into three faunal areas—an eastern humid or Alleghanian, a western arid and a Pacific coast humid division. The Upper Austral zone is divided into two faunal areas—an eastern humid or Carolinian and a western arid or Upper Sonoran area. The lower Austral and Tropical zones are likewise divisible, but since *Epochra canadensis* has not been recorded from any locality belonging to these zones, the divisions need not be considered.

Reliable information on the occurrence of *Epochra canadensis* from specific localities in Canada is exceedingly scarce, and the following discussion on the distribution of this pest is based mainly on doubtful records obtained from infested currants and gooseberries from which the imagoes were not bred. In Canada the currant fruit fly is distributed principally in the Canadian zone. From the data at hand, the northern limit of its distribution seemingly occurs between latitudes 53–54°. The most northern locality from which infested fruit has been reported is Edmonton, Alberta, at an elevation of 2,185 feet. The trypetid also occurs in the Alleghanian, western arid and Pacific coast humid areas of the Transition zone. St. Catherines (360 feet), Ontario, situated between Lake Erie and Ontario is located in the Carolinian area of the Upper Austral zone, but the record is based on “a single red currant fruit with a dipterous maggot in it.”

The present known distribution of *Epochra canadensis* in the United States from reliable records, shows that it occurs in the Canadian, Transition and Upper Austral zones. In table I, an attempt was made to place the various localities into the faunal areas with the use of various maps and descriptions found in North American Fauna. The elevations of the cities were taken from Gannet's (1906, pp. 1–1072) “A Dictionary of Altitudes in the United States,” except where the entomologist stated the elevation at which the currant fruit fly was collected.

TABLE 1.

Faunal Areas in Which *Epochra Canadensis* Occurs in the United States.

State	City	Elevation (feet)	Boreal	Austral region	
				Transition	Upper Austral
Maine	Orono	115—129		Alleghanian	
	Waterville	112		Alleghanian	
New York	New York	7—314			
South Dakota	Rapid City	3196—3244		Western arid	Carolinian
	Hot Springs	3425—3462		Western arid	
	Lead	5119—5329			
Colorado	Spearfish	3637—3647		Western arid	
	Fort Collins	4984—4994			Upper Sonoran
	Boulder	5350			Upper Sonoran
Montana	Ute Creek	9000	Canadian		
Utah	Bozeman	4753—4754	Canadian	Western arid	
Idaho	Richfield	5308		Western arid	
Washington	Moscow	2569—2574		Western arid	
	Canfield			Western arid	
	Pullman	2345—2550		Western arid	
Oregon	Almota	600		Western arid	
	Wentachee	639—669		Pacific coast	Upper Sonoran
	Bellingham	60		Pacific coast	
	Roche Harbor			Western arid	
	Freewater			Pacific coast	
	The Dalles	96—116		Western arid	
	Gresham			Pacific coast	
California	Russellville			Pacific coast	
	Ashland	1868—1940		Pacific coast	
	Salem	120—163		Pacific coast	
	Forest Grove	169—229		Pacific coast	
	Corvallis	227—319		Pacific coast	
	Anderson	428		Pacific coast	Upper Sonoran
	Santa Rosa	165—181		Pacific coast	
	San Mateo	22		Pacific coast	
	Redwood City	8—12		Pacific coast	
	Palo Alto	63		Pacific coast	
	Mountain View	95—124		Pacific coast	
	San Jose	81—118		Pacific coast	
	Watsonville	23		Pacific coast	

The low summer temperature on the Pacific coast permits this species to come as far south as latitude 37°. The most southern locality in which the currant fruit fly has been recorded in California is Watsonville, which is exposed throughout the year to the cold coast fogs. In reference to the vertical distribution, the pest has been captured at Ute Creek (Lat. 37—38°), Colorado, at an elevation of about 9000 feet.

To determine whether the currant fruit fly occurs in any country other than Canada and the United States, specimens of *Epochra canadensis* were sent to various fruit fly specialists who have travelled extensively in various parts of the world. Mr. Geo. Compere, chief quarantine inspector at San Francisco, who has spent nine years of almost continuous travelling over the world in search of fruit fly parasites has never met with *Epochra*

*canadensis* in any foreign country. He has visited Brazil, Spain, Italy, Island of Malta, Hawaiian Islands, Fiji Islands, Australia, Thursday Island, German New Guinea, Java, Philippine Islands, Japan, Malay State, China, India, Ceylon, Asiatic Turkey and Egypt.

Mr. W. W. Froggatt, Agricultural Museum, Department of Agriculture, Sydney, New South Wales, who spent over a year of continuous travel to inquire into the best methods of dealing with fruit flies and other pests and the value of parasites writes, "I have gone through my collection of Australian and foreign fruit flies and see nothing like your *Epochra canadensis*. I have a fairly large collection from various parts of the world both from the East, Pacific Islands and South America and Africa." In his trip he visited the Hawaiian Islands, United States, Mexico, Cuba, Jamaica, Barbados, Panama, England, France, Spain, Italy, Austria, Hungary, Asiatic Turkey, Cyprus, Egypt, India and Ceylon.

Dr. F. Silvestri, Portici, Italy, who has travelled in the Canary Islands and West Africa in search of natural enemies of fruit flies writes, "I have never seen in Italy or elsewhere *Epochra canadensis* and *Rhagoletis pomonella*, therefore, I am very sorry I can not give you any useful information about these species. A careful study of the fruit flies in China and in South America is necessary for being sure about the distribution of the species of some genera."

Dr. T. Miyake, Imperial University, Komaba, Tokyo, Japan, who has made an extensive study of the fruit flies of Japan writes, "As to your inquiry regarding the occurrence of *Epochra canadensis* I should answer the fly is not yet found in our country."

Although the currant fruit fly is said to be "widely distributed in Maine," reliable records are limited to the two following localities: Orono, Penobscot County and Waterville, Kennebec County. Doubtful localities in the various counties of the state of Maine, obtained from records of injury by apparently this same pest published in the Annual Reports of the Maine Agricultural Experiment Station and through correspondence are numerous.

## NATIVE HOST PLANTS.

The native host plants of *Epochra canadensis* are probably the wild currants and gooseberries. The currant fruit fly was bred from the fruit of the wild gooseberry (*Grossularia oxyacanthoides* (L.) Mill.) which were growing in a pasture about a mile from Orono, Maine. On June 28, 1915, 39 per cent of the gooseberries on these bushes contained egg chambers of apparently this trypetid. The fruit of the wild red currant (*Ribes triste* Pall.) was also found to be infested, but it should be noted, however, that the bushes were growing on the banks of a stream at a distance of about 35 feet from some cultivated currant and gooseberry bushes with practically all of the berries wormy. Our observation on the wild black currant (*Ribes americanum* Mill.) was limited to one bush located about 10 miles from Orono, but not a single berry was infested.

The distribution of the wild currant and gooseberry which were found to be infested by *Epochra canadensis* in Maine is as follows:

*Ribes triste* Pall. Newfoundland to Alaska, and south to New Jersey, Michigan, South Dakota, and Oregon; also in northern Asia. *Grossularia oxyacanthoides* (L.) Mill. Hudson Bay to Yukon, British Columbia, Alberta, Montana, North Dakota and northern Michigan.

Coville and Britton (1908, pp. 193-225) record 43 species of *Ribes* and 40 species of *Grossularia* growing, independent of cultivation, in North America. Within the range of *Epochra canadensis* as determined with cultivated fruits, are 15 species of wild currants and 8 of gooseberries occurring both in Canada and the United States; also 11 species of *Ribes* and 18 of *Grossularia* recorded only in the United States.

## DESTRUCTIVENESS TO CULTIVATED FRUITS.

The currant fruit fly is so serious a pest in the state of Maine, that frequently the crop of currants and gooseberries is a total loss. In Orono, some people have dug up and burned their currant and gooseberry bushes, because the fruit was infested with maggots so that it could not be used. One person set

out some currant bushes in an isolated locality in the spring of 1913, and two years later the berries were so badly infested that the crop was not picked. The trypetid was also bred from the fruit of a cultivated shrub commonly called the flowering or mountain currant (*Ribes alpinum* Pursh).

## LIFE HISTORY.

A brief historical account of the life history of *Epochra canadensis*, as determined by a number of entomologists in different localities, is herewith given. According to Harvey's (1895, p. 116) observations in the field, the time required for the eggs to hatch and the larvae to mature is about three weeks, while the pupal stage extends over a period of about eleven months under Maine conditions.

Piper and Doane (1898, pp. 5-6) have worked on the life histories of the dark currant fly (*Rhagoletis ribicola* Doane) and the yellow currant fly (*Epochra canadensis* Loew) in the State of Washington. These scientists make the following statements concerning the life history of the dark currant fly: "The eggs soon hatch into small whitish, footless larvae or 'maggots' which eat their way toward the center of the berries and there feed until fully grown. In about three or four weeks they are ready to pupate." The pupae "pass the rest of the summer and winter in this state, emerging as adult flies the following spring." The authors state that the habits and life history of the yellow currant fly are very similar to that of the dark currant fly.

Paine (1912, pp. 141-142) gives the following contribution on the life history of the yellow currant fly or gooseberry fruit fly (*Epochra canadensis* Loew) in the San Francisco Bay region: "After a period of incubation lasting, in the case of specimens taken into the laboratory, for 11 days, the minute larva or maggot hatches" \*\*\*. The larval period was not determined. The pupa remains in the ground for 10 months.

## EGG AND LARVAL PERIODS UNDER LABORATORY CONDITIONS.

In 1914, the duration of the egg and larval stages of *Epochra canadensis* was determined by the writer, in the different fruits attacked by the pest in Maine under laboratory conditions. The method followed to induce oviposition, was to place a few twigs

of the host plant bearing unripe fruit, in a breeding jar containing fruit flies which had been captured in the field. The bottom of the jar was covered with about an inch of moist sand and in this was embedded, a small bottle of water containing the stems of the plants. The twigs were allowed to remain in the breeding jar for a day and were then transferred into another jar which did not contain flies. At the bottom of the second jar rested a bottle filled with water and in this, the ends of the stems were emersed. The duration of the egg and larval periods in cultivated and wild gooseberries, white and red currants, and the mountain currant (*Ribes alpinum* Pursh) under laboratory conditions is shown in table 2.

TABLE 2.

*Egg and Larval Periods Under Laboratory Conditions.*

Kind of Fruit	Date of Oviposition	Egg period (days)	Date larvae issued from fruit	Number larvae issued	Larval period (days)	Egg+larval periods (days)
Gooseberry -----	June 22	4-5	July 8	1	11-16	16-20
			9	2		
			10	2		
			11	6		
			12	3		
Gooseberry -----	June 23	4-5	July 9	1	11-15	16-19
			10	1		
			11	5		
			12	4		
			13	2	12-14	18-19
Wild gooseberry-----	June 20	5-6	July 8	1		
Wild gooseberry-----	June 21	4-6	July 7	1	10-16	16-20
			8	1		
			9	5		
			10	2		
			11	1		
White currant-----	June 21	4-5	July 7	5	11-14	16-18
			9	2		
White currant-----	June 28	4-6	July 15	3	11-16	17-20
			17	2		
White currant-----	June 30	4-6	July 17	1	11-15	17-19
Red currant-----	June 23	4-5	July 9	1	11-16	16-20
			10	3		
			11	2		
			13	3		
Red currant-----	June 29	4-6	July 15	2	10-17	16-21
			16	5		
			17	2		
			18	2		
			20	1		
Mountain currant-----	June 18	7	July 9	1	14-16	21-23
			10	5		
			11	1		
Mountain currant-----	July 6	5-6	July 23	1	16-18	22-23
			29	1		

It is evident from this table that the egg period required from 4-7 days; the larval stage from 10-18 days and the egg plus the larval periods from 16-23 days in the different fruits.

#### EGG AND LARVAL PERIODS UNDER FIELD CONDITIONS.

In 1915, the duration of the egg and larval periods was determined in gooseberries and red currants under field conditions. No trouble was experienced in causing the trypetids to oviposit in confinement in the field. On June 22, at 6 A. M. 100 female currant fruit flies, which had been captured in the field, were liberated in a cage enclosing a gooseberry bush, and by 6 P. M., all of the specimens had been removed. On June 25, 150 females were set free in a cage covering a red currant bush and at the end of the day the insects were removed. As the minimum larval period under laboratory conditions required 10 days, it was decided to allow the fallen fruit to remain on the soil below ground cages until the tenth day after the eggs had hatched. The drops were then placed in sanitary fruit jars which rested on the ground in the shade but were protected from rains. All fruit which dropped on or after the tenth day was placed in jars immediately. In the containers the fruit soon became covered with fungi and few maggots completed their development compared with the number of infested berries. The duration of the egg and larval periods is shown in table 3.

TABLE 3.

*Egg and Larval Periods Under Field Conditions.*

Kind of Fruit	Date of Oviposition	Egg period (days)	Date larvae issued from fruit	Number larvae issued	Larval period (days)	Egg+larval periods (days)
Gooseberry -----	June 22	7-8	July 11 12 13 14 15 16 17 18 19 20 21 22 24	1 6 11 25 33 37 24 33 10 5 4 3 6	11-25	19-32
Red currant-----	June 25	6-7	July 15 16 17 18 19 20 21 22 23 24 26	198 2 4 6 12 17 4 3 2 1 1	13-25	20-31

A total of 198 maggots issued from gooseberry drops and of this number 178 completed the larval development in two to three weeks, seven required 11-13 days and thirteen, 21-25 days. Fifty-four maggots emerged from the red currant drops, of which number 48 completed the larval period in two to three weeks, two required 13 days and four, 21-25 days.

## PERIOD BETWEEN DROPPING OF FRUIT AND EXIT OF LARVAE.

A method of control recommended is to frequently gather and destroy fallen infested fruit. The length of time between the dropping of the berries and the exit of the larvae has an important bearing on the frequency of collecting drops. A daily record was therefore kept of the gooseberries which dropped from the bush and the dates of the exit of the larvae. The egg chambers in gooseberries which dropped from June 27-July 1,

were opened to determine the egg period and hence no data were obtained on the emergence of the larvae from these berries. Table 4, shows the results.

TABLE 4.

*Dates of Dropping of Gooseberries and Exit of Larvae.*

Dates of exit of larvae	Dates in July of dropping of gooseberries																			Total number larvae	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22	24	
July 11																					1
12																					6
13																					11
14																					25
15																					33
16																					37
17																					24
18																					33
19																					10
20																					5
21	1																				4
22																					3
24																					6

Similar records obtained with currants are given in table 5.

TABLE 5.

*Dates of Dropping of Currants and Exit of Larvae.*

Dates of exit of larvae	Dates in July of dropping of currants														Total number larvae	
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
July 15					1	1										2
16		1						3								4
17	1		2	1		2										6
18			1	1		4		3	3							12
19	2			1	1	2	2	2	2	5						17
20						1	1				2					4
21						1	1					1				3
22																2
23													2			2
24												1				1
26													1			1

If the laborious task of picking up fallen infested fruit has any practical value, it is evident from tables 4 and 5, that the drops must be picked up daily. With this method of control the

first issuance of the larvae from the fruit must be determined. In 1895, Harvey (1895, p. 116) writes, "the larvae began to emerge on June 20." In 1915, the first larvae issued on June 30, but in all probability, the dates would vary in different seasons. We began to pick drops on June 14, 1914, and June 13, 1915, and continued to gather the fallen fruit at least twice a week until the crop was harvested. The results obtained by the destruction of fallen infested fruit are discussed under methods of control.

*Cracked fruit.*—From the same bush a record was obtained of the number of egg chambers in each gooseberry drop and the number of fallen cracked fruit with or without egg cavities. The results are indicated in table 6.

TABLE 6.

*Dates Gooseberries Dropped, Number of Egg Chambers, and Cracked Berries With or Without Egg Cavities.*

Date	Number of gooseberry drops with egg chambers						Total Drops	Drops With No Egg Chambers		
	1 Egg Chamber		2 Egg Chambers		3 Egg Chambers			Fruit cracked	Not cracked	
	Fruit cracked	Not cracked	Fruit cracked	Not cracked	Fruit cracked	Not cracked				
June 27		1					1			
28		1					2			
29		1					3			
30		5					5			
July 1		3					5			
2	8	65	3	50	4	12	142		1	
3	16	99	5	27	1	7	*156		10	
4	23	79	6	24		3	135		3	
5	20	40	3	10	2	1	76	1	5	
6	14	13		2			29		3	
7	11	16	2	3			32	1	1	
8	23	18		1			42		1	
9	3	2		3			8		1	
10	1	5					6		1	
11	18	7	2	1			28		1	
12	17	6					24		1	
13	12	2		1			15		1	
14	4	4					8		2	
15	2	1					3			
16	4	12					16			
17	8	12					20			
18	4	5					9			
19	6	10					16			
20	2	3					5			
21	2	3					5			
22	6	8					14		1	
23	2	3					5			
24	1	7					8			
	207	431	21	127	7	24	818	2	34	

\* Included in the 156 was one cracked gooseberry with four egg chambers.

From table 6, one can readily comput that 29 per cent of the total number of drops having egg chambers were cracked compared with 6 per cent fallen cracked fruit without egg cavities. Gooseberry drops with one egg receptacle showed that 32 per cent were cracked. Similar data were also obtained in checking up the effectiveness of the poisoned bait spray. Drops with egg chambers obtained from a gooseberry bush treated with the poisoned bait showed that 7 per cent were cracked compared with 1 per cent fallen cracked fruit without egg cavities. Gooseberries picked at the end of the season from a check or control bush, showed that 23 per cent of the berries with one egg receptacle were cracked. Cracked currants with egg punctures were also observed among the drops and picked fruit. In all probability, the cracking of the fruit was due to the fact that the tissue had been killed in the formation of the egg chamber and in the further development of the berry cracking resulted due to the interference of this dead tissue to uniform growth.

The first gooseberry dropped from the same bush 5 days after oviposition had taken place and 11 berries dropped before the eggs hatched. The maximum period of dropping occurred on July 2-5, when the larvae which were less than a week old, caused 62 per cent of the fallen fruit. Before the exit of the first larva 78 per cent of the total number of drops containing egg punctures had fallen.

Currants and wild gooseberries may also drop before or after the egg hatches, or the currants may remain on the bush throughout the larval development. The exit hole of the larva (Figs. 14, H. 15, G.) was occasionally found in currants and cultivated gooseberries which were still adhering to the branches.

#### INFESTED UNFERTILIZED BERRIES.

Among the first drops of the season are a large number of unfertilized berries in which the currant fruit fly sometimes deposits its eggs before the fruit falls. Unfertilized gooseberry drops become shriveled, dried and turn black on the ground in about ten days and the larva is unable to complete its development in such berries.

## PROCESS OF OVIPOSITION.

After the process of oviposition was observed with the naked eye in the field, we decided to see with a binocular microscope, the formation of the egg chambers or receptacle in which the egg is deposited. Accordingly, about 100 fruit flies captured in the field, were confined in a large breeding jar which contained currant branches bearing green fruit. After the female fly alights on a berry, it usually walks about as if seeking a suitable place in which to oviposit. Finally the insect comes to rest, cleans off the egg-laying apparatus with its hind legs, and then the last three segments of the abdomen are bent beneath the body at an angle of about 30 degrees (Fig. 17, F). The berry with the trypetid in this position was now cut off with a pair of scissors, and held below the objective of a binocular microscope. One could readily see the telescoped ovipositor move up and down within the seventh tube-like segment. The distal end of the tube-like segment is applied to the fruit, while the teeth-like projections (Fig. 13, G.) at the end of the ovipositor begin to rasp the epidermis of the berry. The puncturing apparatus often slips on the peel of the currant but apparently the tactile bristles (Fig. 13, G.) near the end of the egg-laying organ assist the pest in locating the scraped area. The claws of the middle and hind legs also slip on the berry and as the legs approach the median line of the body, the fly grasps a new hold. During this rasping period, the mouth-parts are constantly protruded and retracted. Finally the teeth-like projections have scraped a small elliptical hole through the epidermis. The adult now endeavors to force the end of the ovipositor beneath the thin skin of the currant, and as the peel is pried loose in the small hole, the abdomen moves up and down. Next the entire length of the ovipositor is forced beneath the epidermis. A small drop of liquid exudes from the hole. In loosening the cuticle the piercing instrument is thrust in different directions, while the abdomen moves from side to side. The membrane between the egg-laying organ and the tube-like segment becomes swollen at the end of each thrust of the ovipositor.

After the egg chamber is completed the imago raises its body on its legs, the abdominal segments become distended, and sometimes the proboscis is protuded stiffly. As the muscles of

the oviduct and oviductus communis expel the egg into the ovipositor, a peristaltic movement of the abdominal segments occurs. The egg can be seen gliding through the membrane connecting the tube-like segment with the egg-laying organ and again, when it passes out of the opening near the end of the ovipositor into the egg receptacle. The ovipositor is then withdrawn, and with the abdomen still bent, the fruit fly walks around on the berry, stops a moment to clean off the egg-laying apparatus with the tarsi of the hind legs and then takes flight.

#### TIME REQUIRED IN PROCESS OF OVIPOSITION.

The time required to rasp through the epidermis of the currant, the time spent in forming the receptacle and depositing an egg and the total time of the entire process of oviposition of ten specimens, which were captured in the field in the morning and allowed to oviposit in the afternoon, is shown in table 7.

TABLE 7.

#### *Time Required in Process of Oviposition.*

Time required to rasp through epidermis	Time required to form receptacle and deposit egg	Total time of oviposition
(minutes)	(minutes)	(minutes)
2	1	3
2.5	1.5	4
3.5	1.5	5
4.5	1.5	6
5	3	8
8	1	9
8.5	2	10
7.5	3.5	12
11.5	4.5	12
	2.5	14
Average	6.1	8.3
	2.2	

The time required to puncture the epidermis depends upon the toughness of the peel, and the general activity of the insect. One female was unable to rasp through the skin of a hard, green, mountain currant and finally deposited several eggs on the outside of the berry at the calyx end. On cold, cloudy days the fruit flies are not active and the process of oviposition is rare and often prolonged. Adults near the end of their natural life were frequently observed rasping the epidermis of currants and

gooseberries for half an hour or more and then failed to break the cuticle. Such specimens were occasionally seen to move the end of the ovipositor against the side of the glass jar.

When a fine needle is used to puncture the epidermis at the region where the fruit fly is rasping the peel, the ovipositor is forced immediately into the hole, a receptacle is formed and an egg deposited. If the needle is thrust into the pulp, the female may push its ovipositor into the hole, but often does not lay an egg.

#### EGG CHAMBER.

It is not difficult to locate the egg cavity containing the egg immediately after oviposition has taken place. Two days after the egg is deposited in a gooseberry, faint indications of brown discoloration appear around the semi-circular mouth of the receptacle. Later the peel over the entire egg chamber becomes brown and very conspicuous. Finally, in some cases after the egg hatches, the epidermis may turn black (Figs. 14, A. 15, C.).

An examination of gooseberries "stung" by the pest but which failed to drop, showed that if an egg did not hatch, or the young larva died, then the brown or black epidermis of the egg cavity usually cracked around all or a part of the margin of the egg chamber or around the shriveled egg. Sometimes the peel ruptured through the center of the egg puncture but in some gooseberries the epidermis remained intact. A corky growth may develop in the pulp beneath the receptacle.

*Number of eggs in egg chamber.*—As a general rule, one egg is deposited in an egg chamber. On a number of occasions two eggs were found in one receptacle in gooseberries. An egg cavity is sometimes formed and yet no egg may be laid within the same.

*Number of egg chambers in fruit.*—The number of egg chambers in a single berry may vary in the different fruits and probably depends upon the abundance of flies. In white, red and mountain currants the usual number of eggs deposited in a single berry is one, but in some cases two were found. In Chautauqua gooseberries from one to six egg punctures were counted, the average being three (Fig. 14, C.) Without exception every berry on two Chautauqua gooseberry bushes was stung by the pest. An inquiry was made concerning previous condi-

tions. The owner informed us that several years ago he had about 50 currant and gooseberry bushes, but as his entire crop had been maggoty for years, he had pulled up and burned all except the two Chautauqua bushes. In all probability, this accounts for the abundance of the pest and the numerous egg cavities in the fruit.

#### PREMATURE RIPENING.

A green currant which had been "stung" repeatedly at 8 A. M., showed indications of red or premature ripening at 6 P. M. A green currant in which one egg was deposited showed a patch of red at the region of the egg chamber two days after oviposition (Fig. 15, B). When two eggs were deposited in a green berry, two patches of red appeared (Fig. 15, A.). When a little pressure was exerted on a prematurely ripened, white currant, in which an egg had been laid four days previously, a small drop of liquid exuded from the mouth of the egg receptacle. Wild gooseberries also show evidence of premature ripening when they are punctured by the pest. A wild gooseberry in which an egg was deposited, turned red at the region of the egg cavity three days after oviposition had taken place.

An attempt was made to determine whether or not the fruit fly injects into the egg chamber, a secretion which causes premature ripening. Although many specimens were observed during the process of egg-laying under a binocular microscope, no liquid was noticed leaving the opening near the end of the ovipositor and entering the egg cavity. As already stated, the membranous segment between the egg-laying organ and the seventh tube-like segment becomes swollen at the end of each thrust of the ovipositor. However, a small amount of clear secretion ejected with each thrust of the piercing apparatus probably could not be seen passing from the opening of the ovipositor into the egg receptacle.

#### MORTALITY OF EGGS AND LARVAE.

A mortality occurs among the eggs and larvae. The percentage of mortality occurring among eggs and larvae in the egg chambers of gooseberries picked on July 14, from two bushes growing in the sunshine was 36 and 48 per cent. The percent-

ages given do not include the mortality of the eggs and larvae in gooseberry drops and no accurate statement can be made of the mortality in the fallen fruit. Our observations on mortality were confined to the egg cavity and hence only dead larvae of the first instar were found. We frequently observed that the eggs of the currant fruit fly were covered with a fungus growth, but this may have been secondarily developed after the eggs failed to hatch. In opening one egg receptacle below a binocular microscope, two small mites were found near an egg. Although natural enemies may attack some of the eggs, the primary cause of the mortality of fertile eggs and larvae in gooseberries is unknown.

#### FEEDING HABITS OF LARVAE.

The minute larva, upon hatching from the egg in the egg chamber, may either penetrate toward the interior of the fruit leaving no external visible trail, or bore beneath the peel forming a tiny winding tunnel which, at its maximum length, may extend almost completely around a currant or half way around a gooseberry (Fig. 14, D). At first the trail is light colored but later it turns brown and becomes quite conspicuous. A dissection under a binocular microscope of the tunnel leads to the region where the larva is feeding. The recently hatched larva may feed for a time in the pulp between the peel and seeds, but later it may partly or entirely eat its way into a seed.

As the larva grows the seeds become too small to hold the maggot and the larger larva is commonly found partly within or between the seeds or in the pulp. After a larva has devoured the embryo of a currant seed, the posterior end of the body may remain within the seed coats while the mandibles (Fig. 13, G) of the protruding anterior end gnaw holes in the neighboring seeds, or the body may be withdrawn from the seed coats and the larva may then be found with the head region buried in a seed and the caudal part protruding (Fig. 13, A). In other cases, both ends of the body may be within two currant seeds, the posterior portion being within the empty seed coats and the anterior part within a hole of another partly devoured seed.

An examination of currants after the exit of the larva showed that in some cases the embryo of every seed was con-

sumed, but in other instances, some of the seeds were not injured. In one currant 9 empty seed coats were counted and in addition, the embryos of two seeds were partly devoured. As a general rule, however, less than half a dozen seeds are destroyed in each currant. Within some of the seed coats brown particles may be found and these apparently are the excrement of the maggot. In the pulp, these particles are glued together. The brown mass sometimes contains the exuvia of the larva, the black molted mandibles being conspicuous under a binocular microscope.

#### RESPIRATORY PORE.

Sometimes a small hole is present in the peel of currants (Fig. 13, R) and gooseberries which is apparently used for the purpose of respiration by the maggot. A larva was frequently found in berries with the posterior spiracles near the respiratory pore. This breathing pore is absent in fruit containing larvae in the early stages of development. When the maggot issues from the fruit it usually bores through and enlarges the respiratory hole, so that berries which show the exit hole usually do not show the breathing pore. Within the respiratory hole of a Chautauqua gooseberry six small oval eggs were found, evidently of some parasite.

#### EXIT HOLE.

When the larva is full grown it forces its way through the pulp, either cuts a hole through the peel (Fig. 13, E) or enlarges the respiratory pore (Fig. 14, H), and issues from the berry. This exit hole is partly enclosed by the ragged edges of the epidermis (Fig. 15, G) which was severed by the larva. A tunnel with the wall composed of brown particles can be traced to the exit hole in gooseberries.

#### JUMPING HABIT OF LARVAE.

After burrowing out of the fruit, the mature larva often exhibits a peculiar jumping habit. The maggot first slowly arches its body in a circle (Fig. 13, B); the posterior spiracles are next invaginated while the pair of hooked mandibles (Fig.

13, G) attach to a fold at the lower end of the body; the curled body then leans back as far as possible (Fig. 13, C); the jaws suddenly loosen their hold and finally the larva springs into the air. Often the maggot arches its body but may experience difficulty in attaching its jaws to the fold; the larva may then fall over on its side, and although the body is straightened out suddenly, it does not raise from the substratum. Instead of falling on its side, the maggot may topple on its back, and in this case, the larva immediately rights itself.

The maximum height of the jump is  $2\frac{1}{2}$  inches and the maximum distance 6 inches. Fifteen different larvae jumped the following distance; 1,  $1\frac{1}{2}$ , 2, 2,  $2\frac{1}{2}$ ,  $2\frac{1}{2}$ ,  $2\frac{1}{2}$ , 3, 3, 3,  $3\frac{1}{2}$ , 4 and 6 inches, or an average of 2.8 inches.

An experiment was performed to determine the effect of a wet and dry substratum on the jumping reaction. Soil could not be used, for many of the maggots would burrow into the ground, and hence filter paper was employed instead. A dozen mature larvae were placed on wet filter paper and another dozen on dry filter paper. The number of jumps during five minutes were as follows: wet filter paper 22, dry filter paper 8. This experiment was repeated with the same number of different maggots with the following results: wet filter paper 6, dry filter paper 4.

The above experiment was repeated, but after a record was taken of the number of jumps during five minutes, the 12 larvae on the wet filter paper were transferred to the dry and vice versa. The following figures indicate the results: wet filter paper 26, dry filter paper 5; transferred from wet to dry filter paper 0, from dry to wet filter paper 12. This experiment was repeated with the same number of different maggots with the following results: wet filter paper 16, dry filter paper 3; transferred from wet to dry filter paper 0, from dry to wet filter paper 14.

It is evident that a wet substratum such as was used in these experiments increased the number of jumps of the larvae. Mally (1904, p. 10) of South Africa, noticed that when a Mediterranean fruit fly larva jumped out of a collecting box and struck the ground at a temperature of  $142^{\circ}$  F., the maggot began to jump at a lively rate and in five minutes it was dead.

## PUPAL PERIOD.

After the larvae emerge from the fruit they enter the ground to a depth of from one to three inches to pupate. The pupal period may vary between 10 and 11 months.

## EMERGENCE OF ADULTS.

Shortly after the adult emerges, the wings are small curled masses projecting from the thorax. While the organs of flight are expanding the fly strokes them on the upper and lower surfaces with the hind legs and at times separates the two wings. In 15-20 minutes, after the insect has come to rest, the wings are expanded. The opaque appendages first show faint indications of markings which later become more conspicuous as they dry. At this time the wings are held parallel to the long axis of the body and not in the characteristic trypetid manner. The ptylium may still be inflated after the wings are expanded. Normal flight occurs about an hour and a half after the first appearance of the fruit flies above the ground.

Adults with deformed wings were sometimes reared under laboratory conditions. On May 29, 1914, several flies with one or both wings not fully expanded were taken on the ground below currant bushes.

While the wings are expanding, the segments of the abdomen are pushed out as far as the membrane connecting the metameres will allow. The abdomen of both sexes projects beyond the tips of the recently expanded opaque wings at this time, but does not after the wings are dry. At first the abdomen of the female is curled down so that the seventh tube-like segment containing the ovipositor rests against the substratum, but after the wing pattern becomes more marked, the tube-like segment is turned upward. Finally the membranes between the metameres become invaginated, thus pulling the segments into their normal position. The female may now draw the end of the ovipositor along the substratum and expel a trail of liquid from the egg-laying organ. A red spot on each side of the fifth abdominal segment is present in the male upon emergence but this is absent in the female.

*Dates of emergence of adults.*—To ascertain the dates of emergence of *Epochra canadensis*, a cage (height 38, length 60,

width 38 inches) with top and sides of wire netting of the mesh used for mosquito screen was placed over a white currant bush. Soil was banked and tamped around the bottom of the cage to prevent the escape of any of the flies but the ground under this bush had not been disturbed. Table 8, shows a daily record of emergence of male and female currant fruit flies in 1914. The weather records were copied from the weather bureau reports taken at the University of Maine.

TABLE 8.

*Dates of Emergence of Adults in 1914.*

Date	♂	♀	Total	Maximum temperature	Minimum temperature	Precipitation
May 21	0	1	1	82	42	
22	0	1	1	78	57	
23	0	0	0	74	54	
24	0	0	0	71	44	
25	3	9	12	74	48	
26	6	15	21	86	54	
27	8	21	29	88	61	
28	16	40	56	88	59	
29	62	77	139	78	40	
30	25	29	54	69	46	—
31	32	34	66	78	38	
June 1	38	37	75	79	55	.11
2	14	6	20	73	45	
3	14	1	15	66	37	
4	*	*	*	67	40	.31
5	4	2	6	61	42	1.20
6	7	3	10	70	42	
7	18	6	24	63	38	
8	2	1	3	78	45	—
9	2	0	2	72	34	.14
10	0	0	0	75	46	.10
11	1	0	1	84	61	
	252	283	535			

\* No record was taken due to heavy rains. — Indicates a trace of rain.

In the season of 1915, the dates of emergence of the adults under natural conditions was again determined by placing cages over or under currant and gooseberry bushes. Six cages covering 85 square feet of soil enclosed four red currant, one white currant and one gooseberry bush. Eighteen ground cages with top of screen wire and board sides covered 39 square feet of ground below currant and gooseberry bushes. Table 9, gives a daily record of the emergence of male and female currant fruit flies in these cages:

TABLE 9.

*Dates of Emergence of Adults in 1915.*

Date	♂	♀	Total	Maximum temperature	Minimum temperature	Precipitation
May 22	1	1	2	68	47	
23	0	5	5	76	56	
24	4	6	10	77	49	
25	34	31	65	77	43	
26	*	*	*	76	52	.93
27	27	29	56	61	25	
28	14	5	19	57	35	
29	10	14	24	56	36	
30	43	43	86	71	32	
31	79	66	145	76	49	
June 1	44	46	90	83	42	
2	21	37	58	84	41	
3	25	13	38	70	31	
4	12	12	24	72	37	
5	43	28	71	82	42	
6	14	12	26	80	46	
7	16	11	27	81	60	
8	19	3	22	77	57	.04
9	5	6	11	74	49	
10	1	2	3	75	48	.87
11	1	2	3	73	44	.10
12	4	1	5	72	51	
13	1	2	3	73	44	
14	2	1	3	77	50	
15	0	0	0	81	51	.16
16	1	0	1	77	49	
17	0	0	0	79	52	.80
18	0	1	1	81	56	.03
	421	377	798			

\* No record was taken due to heavy rains. — Indicates a trace of rain.

A comparison of the data in tables 8 and 9, shows that the flies began to issue on May 21, 1914, and May 22, 1915, reached the maximum period of emergence on May 28-June 1, 1914, and May 30-June 1, 1915, and the emergence gradually diminished from June 2-11, 1914, and June 2-18, 1915. The period of emergence covered about three weeks in 1914, and four weeks in 1915.

Records were taken to determine whether the kind of soil effects the dates of the first and last emergence of the adults. Table 10, shows the details:

TABLE 10.

*Dates of First and Last Emergence of Adults With Different Soils.*

Dates, first and last emergence	Kind of soil	Kind of fruit	Bush in shade or sunshine
May 22—June 18	Loose soil covered with manure	Red currant	Sunshine
May 30—June 14	Loose soil covered with manure	White currant	Sunshine
May 27—June 13	Loose soil covered with manure	White currant	Sunshine
May 25—June 12	Loose soil covered with manure	Gooseberry	Sunshine
May 22—June 5	Loose soil	Red currant	Sunshine
May 27—June 2	Soil covered with coal and wood ashes	White currant	Sunshine
May 25—June 9	Sod	Red currant	Sunshine
May 27—June 4	Sod	Red currant	Partial shade
May 31—June 5	Clay	Red currant	Shade

If the dates of emergence of the adults are compared in the cases where loose soil was covered with manure, it is evident that there is a difference of 3-8 days between the first issuance of the flies and 1-6 days between the last emergence. The maximum emergence occurred on May 31-June 2, in each instance. The records were obtained in the same garden, the cages were within a few feet of one another and the kind of soil, conditions of moisture and sunshine were apparently the same. It may be possible that from puparia which are near the surface of the ground the flies issue first while from those deeper in the soil the trypetids emerge later in the season. Again, early and late maturing larvae may have some effect on the duration of the pupal period. Data on such factors are necessary before definite conclusions can be drawn.

#### SEXUAL MATURITY.

Of 35 trypetids which issued on May 20, one pair was observed in copula (Fig. 17, E) on May 30, 10 days after emergence under laboratory conditions. To determine how soon mating takes place under natural conditions, currant fruit flies were marked by amputating part of a leg and then set free in a currant and gooseberry garden. A specimen which issued on June 3, was marked and liberated on the same day and was taken

in coition on June 8, five days after emergence. The average maximum temperature was 77° F. and the average minimum temperature was 42° F. for the five days. Males which are sexually mature can usually be recognized by the lateral expansion of the abdomen, but later in the season this is not always a reliable characteristic.

#### MATING PERIOD.

Under natural conditions, the period of mating was determined in a commercial currant and gooseberry garden, consisting of 100 bushes. On June 7, 1914, 38 specimens were collected on the outside of two cages enclosing currant bushes and of these, three pairs were copulating. Three hundred trypetids were taken under scantlings of fences on June 9-10, and 21 pairs were noted in coition. One pair was caught in copula on a limb of a poplar tree 30 feet above the ground. A single pair of fruit flies in coition were taken in the field as late as July 10. From these observations it is evident that mating extended over a period of 33 days.

In 1915, mating commenced in the same currant and gooseberry garden on June 7, and ceased on July 6, thus covering a period of 29 days (Table 18). In another currant and gooseberry patch at a distance of about a mile from the commercial garden, mating began on June 6, and the last pair in coition was captured on July 15, a period of 38 days.

#### PREOVIPOSITION PERIOD.

An attempt was made to determine the number of days required before fully developed eggs appeared in the ovaries, after the adults issued from the pupae. Fruit flies upon emerging were consequently confined in glass jars, the bottom of which was covered with about an inch of sterilized sand and the top enclosed with cheese cloth. The insects were fed daily on diluted corn syrup and fresh bananas. Several times during each day, water was applied to the cheese cloth with a small sponge fastened to a stick. After the trypetids had been kept in captivity for a period varying from 7-16 days, the flies were dissected, the ovarioles were mounted *in toto*, and a record was

taken of the number of ripe eggs found in the ovaries. Table 11, indicates the results:

TABLE 11.

*Period After Emergence Before Eggs are Developed.*

Date of emergence	Date of dissection	Days flies were kept in jars	Number of flies dissected	Number of ripe eggs in ovaries	Number of flies without ripe eggs in ovaries
May 14	May 30	16	10	1	8
16	30	14	10	2	9
20	30	10	10	2	8
June 1	June 8	7	25	2 6 1 1 3	22

In all probability, the effect of confining the insects in breeding jars, as well as the food material employed, plays an important part in the rapidity and number of eggs developed.

An attempt was made to determine the duration of the pre-oviposition period under field conditions. On the day that the adults emerged in cages under natural conditions they were removed, marked by amputating part of a leg, and liberated in a currant and gooseberry garden. Two hundred females were released in six different marked lots on May 31-June 5. During the season, twenty marked insects were captured from the 200 that had been set free.

The shortest preoviposition period required 6 days under field conditions but from the data at hand, no conclusions can be drawn as to the maximum and average periods. As already stated, a specimen which issued on June 3, was marked and liberated on the same day and was taken in copula on June 8, five days after emergence. On June 9, six days after the female issued, she deposited 29 eggs in gooseberries. The average maximum temperature was 77° F. and the average minimum temperature 46° F. for the six days. On the other hand, a marked trypetid which issued on June 1, was not at the egg-laying stage on June 8, when it was captured, seven days after emergence. In this case the average maximum temperature was 79° F. and the average minimum temperature was 44.5° F. for

the 7 days. The last marked fly was caught 25 days after liberation.

#### EGG-LAYING PERIOD.

In the season of 1914, female fruit flies were captured in the field and dissected to ascertain when ripe eggs appear in the ovaries, and thus a clue might be obtained as to the date that egg-laying is likely to begin under natural conditions. No fully developed eggs were found in the internal reproductive organs of specimens captured during the last week in May. On June 6-7, 80 per cent of the females collected contained full grown eggs in the ovarioles. Females which are at the beginning of the egg-laying stage can usually be recognized by the expansion of the abdomen.

Since the earliest date that egg-laying is likely to begin under natural conditions has an important bearing on when to apply the first application of the poisoned bait spray, female flies were again captured in the field in the season of 1915, and dissected to determine when mature eggs appear in the ovaries. Table 12, shows the data.

TABLE 12.

*Dissections of Flies Captured in Field to Determine When Ripe Eggs Appear in Ovaries.*

Date flies were captured	Number of flies dissected	Number of flies with ripe eggs in ovaries	Number of flies without ripe eggs in ovaries
May 25	12	0	12
30	13	0	12
31	13	0	13
June 1	5	0	5
2	16	0	16
3	11	0	11
4	20	0	20
5	41	12	29
6	8	1	7
7	37	24	13
8	50	36	14

Ten female currant fruit flies captured in copula on June 17, 1914, and 12 females on June 11, 1915, were dissected and fully developed eggs were found in the egg tubes of all of them.

During the season of 1914, the first oviposition observed in the field was on June 6. Numerous flies were seen depositing eggs on the warm days of June 11, 12 and 13. The last female laying eggs was captured on July 10. The egg-laying period therefore, covered 34 days.

In 1915, the first oviposition in currants under natural conditions occurred on June 9, and the last on July 15. The deposition of eggs in this year extended over a period of 36 days.

#### NUMBER OF RIPE EGGS IN OVARIES.

Ovarian tubules mounted *in toto* dissected from currant fruit flies which were copulating in the field early in the season, show that there were usually five eggs present in each tubule. The lowest egg in each ovariole was considered mature when no nurse cells were present. When the egg tubes were treated with hot carbolic acid or clove oil and mounted in balsam on a slide, an unripe egg became clear, while a full grown egg appeared opaque under a microscope by adjusting the mirror and shutting off some of the light. Above the second proximal egg in each tubule is a nutritive or yolk chamber which is filled with a mass of nurse cells. The eggs anterior to the second one, however, are surrounded by nurse cells. The average number of full grown eggs in the two ovaries of 10 specimens captured mating in the field on June 7-8, 1915, was 7. The largest number of fully developed eggs counted in the two ovaries of one female was 17 and the smallest number in another specimen was three (Table 13).

#### NUMBER OF OVARIOLES IN OVARIES.

Each ovary is made up of a variable number of egg tubes, there being usually between 15-18. Table 13, shows the number of ovarioles and ripe eggs in 10 specimens which were copulating in the field early in the season.

TABLE 13.

*Number of Eggs and Ovarioles in Ten Currant Fruit Flies.*

Date, flies were mating in field	Ovarioles in right ovary	Left ovary	Total in both	Number of ripe eggs in ovaries
June 7	16	16	32	4
7	17	17	34	17
8	16	15	31	3
8	15	16	31	10
8	17	15	32	10
8	16	17	33	5
8	17	17	34	5
8	17	17	34	7
8	17	18	35	8
8	18	18	36	4
Average	16.6	16.6	33.2	7.3

If the five eggs present in each of the 33 ovarioles were to reach maturity, the female would be able to deposit 165 eggs; but since many more eggs may be developed in the terminal chamber, the question of the number of eggs that a fly may lay remains doubtful.

#### DAILY RATE OF OVIPOSITION.

An attempt was made to ascertain the daily rate of oviposition under laboratory conditions. Three pairs of currant fruit flies in coition were confined in three glass jars. The bottom of each container was covered with about an inch of moist sand, in which was embedded a small bottle of water containing the stems of gooseberry twigs heavily laden with fruit. At the end of each day the twigs were removed and replaced by others cut from a screened gooseberry bush. The trypetids were fed daily on diluted corn syrup. Several times during each day water was applied to the cheese cloth enclosing the top of the jars. Table 14, shows the daily rate of oviposition.

TABLE 14.

*Daily Rate of Oviposition.*

Date	Fly No. 1	Fly No. 2	Fly No. 3
June 12	*		
14	2	*	*
15	8	4	
16	33	23	5
17	5	14	0
18	4	8	0
19	5	4	4
20	5	2	1
21	2	5	29
22	4	2	13
23	0	0	0
24	1	0	0
25	0	0	3
26	2	3	5
27	0	0	0
28	6	3	7
29	0	0	3
30	2	1	2
July 1	0	0	2
2	1	1	2
3	1	1	0
4	0	0	1
5	0	0	1
10	1	0	0
12	0	0	2
13	0	0	1
18	+	0	0
20		+	0
Aug. 1			+
	— 82	— 71	— 81

\* First mating.      + Died.

One or two days after the first mating, the females began to oviposit and within a week they reached the maximum egg-laying stage, depositing as high as 23-33 eggs in a day. After this period was reached the number of eggs laid decreased and on many days no eggs were deposited. Frequently the flies formed an egg cavity but did not deposit an egg. One specimen formed 31 chambers from July 14-28, and during these two weeks not a single egg was laid. In all probability, the effect of confining the currant fruit flies in jars and also limiting the food material to corn syrup and water, had a marked effect on the egg-laying capacity.

## LONGEVITY OF ADULTS.

According to tables 8 and 9, the first flies emerged on May 21, 1914, and May 22, 1915, in a commercial currant and goose-

berry garden, and the last specimens issued on June 11, 1914, and June 18, 1915. During two seasons, the last trypetids were captured on July 10, in this commercial garden, and if these insects emerged on June 11 and 18, the longevity of the adults would have been 29 days in 1914, and 22 days in 1915. In another currant and gooseberry patch at a distance of about a mile from the commercial garden a male currant fruit fly was captured as late as August 12, 1915. The last date of emergence was June 18, making the longevity of this imago apparently 55 days. Under laboratory conditions, however, a few specimens of *Epochra* were kept alive in jars for a period of 9 weeks.

An experiment was performed to determine the longevity of marked male and female currant fruit flies under natural conditions. Trypetids were removed from cages in the field, marked with different colored waterproof inks, and were set free in a currant and gooseberry garden on the same day that they issued. One hundred thirteen male and 74 female flies were released in two differently marked lots. No attempt was made to capture any flies during the first two weeks. During the third week 15 males and 14 females were caught in shady localities in the currant and gooseberry garden and during the fourth week three males and two females were taken. The last male was captured 29 days after liberation, and two females were collected after 30 and 31 days of freedom.

#### ONE BROOD ONLY.

According to Paine (1912, p. 142) "the only evidence that suggests a second brood, is the report of a single specimen of *Epochra canadensis* collected at Redwood City late in summer." A male currant fruit fly was captured by the writer as late as August 12, 1915, at Orono. This specimen was caught in the shade on a limb of an apple tree which was growing among currant and gooseberry bushes.

During the season of 1914, 121 quarts of infested gooseberries were taken into an insectary of the enclosed type to determine whether a second brood of flies would emerge. This building was provided with a glass roof sprayed with whitewash, a number of windows in the two sidewalls and two screen doors, one in each endwall. The fruit was allowed to remain within the insect-house until the larvae completed their development.

From a portion of the infested berries, 12,154 puparia were obtained. The puparia were placed in moist sand in glass jars with cheese cloth covering the mouth of each container. The jars were transferred from the insectary to a laboratory and were kept out of direct sunlight. On August 9, two female currant fruit flies emerged and by the end of the month 17 trypetids had issued. Of this number 11 specimens were apparently normal but 6 were abnormal due to the fact that the wings did not expand properly. This abnormality may have been caused by the loss of moisture from the sand. A few adults emerged also during September.

If a second brood of flies issued under natural conditions, one would expect an infestation of such berries as were overlooked by the pickers after the crop was harvested. Accordingly, currants and gooseberries were gathered on August 15, and placed on sand in breeding jars. One month later the sand was sifted but no puparia were found.

In view of the fact that conditions were not normal under insectary and laboratory conditions, it was decided to determine whether a second brood occurred under field conditions. During the season of 1915, 101 quarts of infested gooseberries were distributed in four large cages (height 35, length 36, width 31 inches) with top and sides made of mosquito wire. The varying soil conditions with reference to sunshine and shade under which the cages were placed over the infested gooseberries in the field are indicated in table 15. The cages were visited daily except on heavy rainy days. In none of the cages did a single adult emerge. There is no evidence of a second brood under natural conditions at Orono, Maine.

TABLE 15.

*Soil Conditions Under Which Cages Were Placed Over Infested Gooseberries to Determine Whether a Second Brood Occurs.*

Cage	Location	Soil	Sunshine or shade	Infested gooseberries	Dates drops were gathered
No. 1	Adjacent to barn	Sod removed from rich black soil	Partial shade	31 qts.	June 13-26
No. 2	Hay field	Sod	Sunshine	32 qts.	June 27-July 3
No. 3	Forest	Plowed clay	Shade below alder tree	22 qts.	July 4-10
No. 4	Orchard	Tufts of grass growing in clay	Shade below apple tree	16 qts.	July 11-17

## SUMMARY OF DURATION OF STAGES IN LIFE HISTORY.

The duration of the different stages in the life history, the mating, preoviposition, egg-laying periods and the longevity of the adults as determined under laboratory and field conditions are summarized in table 16.

TABLE 16.

### *Summary of Duration of Stages in Life History Under Laboratory and Field Conditions.*

Stages in life history	1914 (days)	1915 (days)
Egg period.....	* 4—7	6—8
Larval period.....	* 10—18	11—25
Pupal period (months).....	10—11	10—11
Mating period.....	33	33
Preoviposition period.....	* 7—16	6
Egg-laying period.....	34	36
Longevity of adults.....	729	29—31

\* Laboratory conditions.

## HABITS AND BEHAVIOR OF ADULTS.

### FEEDING HABITS.

The only observation on the feeding habits of *Epochra canadensis* made in 1914, was that of a single female fly which was seen feeding on a currant flower on May 25. During the following season, the adults were frequently noticed lapping up honey-dew from plant lice infesting currant leaves.

### STARVATION EXPERIMENTS.

A series of experiments were performed to determine the number of days that currant fruit flies would live in captivity on water and without water. Shortly after emerging from pupae, one lot of trypetids was confined in a glass jar with the top enclosed by cheese cloth. On the same day another lot of specimens collected in shady localities in the field was placed in captivity in a similar glass container. Four times daily either distilled or lake water was sprayed through the cheese cloth into

the jars with atomizers. The jars were kept out-of-doors in the shade and were protected from the rain. The daily death rate is indicated in table 17.

TABLE 17.

*Daily Death Rate of Currant Fruit Flies Fed on Water and Without Water.*

Adults confined after emerging	Adults captured in field	Access to distilled water	Access to lake water	No water	Daily Death Rate					
					1	2	3	4	5	Days
49	38	49 38			6	14	17	12		Flies
28	21		28 21		3	15	18	2		Flies
21	28			21 28	2	5	15	5	1	Flies
					2	9	5	3	2	Flies
					5	12	4			Flies
					9	16	3			Flies

It is evident that the currant fruit flies can not subsist on water alone.

#### INACTIVENESS ON COLD DAYS.

It was observed in the field that currant fruit flies are so numb on cold cloudy days that they are unable to take wing. When disturbed on such days the trypetids would hop and then drop to the ground. During the night of May 27, 1915, the minimum temperature registered 25° F., and during the next two cold days (Table 9, May 28, 29) the adults were sluggish and inactive.

#### ADULTS SEEK SHADE.

Currant fruit flies seek shady localities in the field. Large numbers of specimens were captured in the shady parts of a wood pile, beneath the scantlings of fences, on fence posts, on trunks and branches of trees, and on branches of raspberry, blackberry, currant and gooseberry bushes. It was frequently observed that during the morning hours, the pest could be collected in certain shady places, and yet when the hot sunshine struck these same localities toward noon or afternoon, not a single trypetid could be found.

In the season of 1915, a daily record was kept of the number of trypetids which were captured in shady localities of a commercial currant and gooseberry garden. After mating commenced in the field, data was taken on the number of male and female flies caught during the morning and afternoon and also on the number taken in copula. Our records are not complete, however, as we were unable to visit the garden on some mornings, as indicated by a vacant space in the column of figures in table 18. An asterisk (\*) in a space indicates that no specimens were captured due to heavy rains and an asterisk preceding a figure, that collecting was discontinued on account of rain.

TABLE 18.

*Male and Female Currant Fruit Flies Captured in Shady Localities and Number Mating.*

Date	♂	♀	A. M. ♂	P. M. ♂	A. M. ♀	P. M. ♀	Mating A. M.	Mating P. M.	Total
May 23	1	3							4
24	*0	*4							*4
25	3	8							11
26	*	*							*
27	0	1							1
30	9	9							18
31	22	32							54
June 2	19	16							35
3	12	13							25
4	12	20							32
5	35	25							60
6	16	8							24
7		*	87		*	47	*	6	140
8		*20	38	*12	44	*8	8		*130
9		47	43	21	27	8	8		154
10		*	3	*	11	*	6		20
11		4	*26	7	*106	0	*24		*167
12		*	56	*	63	*	22		141
13			24		58		2		84
14			28		63		14		105
15		13	*0	13	*1	4			*31
16		64	34	24	55	4	18		199
17		*	*3	*	*14	*	*0		*17
18		*	23	*	39	*	12		74
19			22		58		8		88
20		*	*	*	*	*	*		*
21		44	25	16	27	4	18		134
22		43	18	9	30	14	4		118
23		*	0	*	1	*	0		1
24			0		1		0		1
25		11	32	11	34	0	0		88
26		27	11	3	9	4	16		70
28		15	7	10	12	0	6		50
29		12	11	2	13	2	2		42
30		11	2	3	4	4	0		24
July 1		*	*	*	*	*	*		*
2			*1		*2		*4		*7
4			0		1		0		1
6		2	4	0	3	0	2		11
7		0		0		4			4
8		*	*	*	*	*	*		*
9		*	*	*	*	*	*		*
10			2	0	0	0	0		2
	129	139	315	498	131	723	56	180	2171

If one compares the total number of male and female currant fruit flies captured in shady localities during the morning and afternoon on the dates when no rain fell, it is evident that more males were caught during the forenoon (278♂ A. M., 187♂ P. M.), but more females were collected during the afternoon (99♀ A. M., 214♀ P. M.). A similar comparison of the number of specimens taken in copula on these dates shows that 20 pairs were captured in the forenoon and 37 pairs during the afternoon.

#### EFFECT OF SUNSHINE.

On several occasions currant fruit flies which had been captured in phials in the field were left accidentally in the sunshine and the exposure usually resulted in the death of the specimens. In order to obtain accurate data on the effect of temperature on the trypetids, five male and five female flies were exposed to sunshine in corked phials at 100° F. and within 10 minutes all of them were dead.

#### DEATH FEINT.

The recently emerged trypetids with wings not yet expanded can be induced to feign death. To bring about this inert condition, the fly was suddenly turned upon its back with a camel's hair brush or when disturbed the insect may hop, drop to the ground and feign death. Some specimens could be placed in 6 successive feints. The duration of the successive feints varied from a few seconds to three minutes. The termination of this immovable state was preceded by a twitching of the legs. A gust of wind or a breath of air caused an immediate awakening.

#### MARKING FLIES.

A number of different methods were used in marking currant fruit flies so that they might be recognized in the field. As already mentioned one method employed was to amputate part of a leg. A phial containing one adult was turned with the open end down and the bottle was then tapped with the finger over a small tablet of white paper coated with diluted corn syrup upon which the insect usually began to feed. The tablet was then turned in the desired position and a leg was snipped in two

through either the tarsus or tibia with a sharp spear-pointed needle. After part of the leg was severed, many flies continued to feed and showed no external indication of pain; others, however, flew to the windows, apparently from the shock effect of the operation. Every specimen was then captured in a phial and examined under a binocular microscope to determine whether the same leg was cut in each lot of trypetids.

Another method of marking currant fruit flies was with the use of different colored waterproof inks. A droplet of ink was applied with a small camel's hair brush to the thorax between the wings, while the adults were at rest on a mosquito screen wire enclosing an open window, where the ink dried quickly. Each specimen received at least three coats of ink. Higgin's scarlet, yellow and indigo blue waterproof inks formed an even coating, and gave better results than black or india ink. The difference in color between scarlet and yellow, indigo blue and black could not be distinguished with certainty after marking the flies. In some experiments the insect were doubly marked; first by amputating part of a leg, and second with the use of a waterproof ink.

The adults were handled before and after marking in a manner so that they were not injured. The flies were captured by holding a wide-mouthed phial over each trypetid and then the bottle was corked. After each specimen was marked, it was again captured in a phial and transferred through a hole in cheese cloth covering the top of a jar. The hole was plugged with cotton. The bottom of the container was covered with about an inch of moist sterilized sand.

#### FLIGHT OF MARKED FLIES.

Marked flies were set free in the field in order to determine how far they might travel, and also what effect winds may have on the flight. In releasing the specimens, the jar was placed on the ground, the cotton plug was removed and the hole was enlarged with a pair of scissors until the mouth of the container was free from the cheese cloth. The orientation of marked trypetids with reference to winds was carefully noted with the liberation of each lot of insects. When a heavy wind was blowing, the marked diptera flew and were carried by the wind with

extreme rapidity. In no case did the adults attempt to orient themselves against even a light breeze. During a calm spell no orientation took place and the fruit flies darted off in all directions.

Three hundred trypetids were liberated in four different marked lots, containing from 50-150 specimens. Each lot was set free from a different locality at a varying distance from a commercial currant and gooseberry garden consisting of 100 bushes. One person collected currant fruit flies daily in shady localities in this garden. During the season 2188 adults were caught and of this number 17 were marked individuals from the 300 that had been released. All of the 17 marked insects were captured during the first 15 days after the experiment had been started.

Table 19, shows the dates on which the fruit flies were released, the number of doubly marked trypetids in each lot, the direction of the wind at the time of liberation, the distance from the point of liberation to the commercial currant and gooseberry garden and the dates on which marked specimens were captured:

TABLE 19.

*Data on Experiments With Marked Currant Fruit Flies.*

Dates of liberation	Number of flies liberated	Leg cut; color of ink	Direction of wind	Distances flies were captured	Dates flies were captured
June 13 P. M.	115♀ 35♂ 150	Right middle leg; yellow	Heavy S. W.	3290 ft.	June 16, 1♀ 18, 1♀ — 2
14 P. M.	50♀	Left hind leg; scarlet	Light S. E.	2650 ft.	16, 1 29, 1 — 2
14 A. M.	50♀	Left middle leg; indigo	Light N. W.	1115 ft.	15, 1 16, 1 21, 1 25, 1 26, 1 — 5
18 P. M.	50♀	Right hind leg; indigo	Calm	300 ft.	19, 1 22, 3 23, 1 25, 2 28, 1 — 8

The first lot of 150 fruit flies were set free on an island during a moderate southwest wind which blew toward the commercial currant and gooseberry garden. An examination of the vegetation on this island showed the presence of a few wild gooseberry bushes. As indicated in table 19, two marked females were captured in this garden at a distance of 3290 feet from the point of liberation. These specimens were forced to fly across a bay of the Penobscot River, varying from 200-500 feet in width.

The second lot of 50 marked trypetids were released on the side of a hill at an elevation of about 50 feet, during a light southeast wind which blew directly away from the commercial currant and gooseberry garden. Two marked females were captured in this garden at a distance of 2650 feet from the place of liberation. The two adults were collected after 2 and 15 days of freedom. These specimens may have been caught up by changes of winds which carried them towards this currant and gooseberry patch, or they may not have made a continuous flight but a series of short flights which finally brought them into this garden without the influence of the wind.

The third lot of marked adults were freed on a level stretch of country with no barriers, such as rivers or hills between the point of liberation and the commercial currant and gooseberry garden. At the time that the specimens were released, a light northwest wind was blowing toward the garden. Within 12 days five marked fruit flies were captured in this garden at a distance of 1115 feet from the place of liberation.

In the last experiment we endeavored to determine whether marked fruit flies when liberated in a gooseberry patch located in a yard in the residential section would travel to the commercial currant and gooseberry garden. This problem is a matter of much concern economically, if control measures are adopted in a non-isolated currant or gooseberry patch. Fifty marked females were set free by placing the jar containing the specimens on the sod in tall grass under a gooseberry bush. The flies gained their freedom during a perfectly calm spell. Within ten days eight marked specimens were captured in the commercial currant and gooseberry garden at a distance of 300 feet from the place of liberation.

## NATURAL ENEMIES.

To determine whether a parasite checks somewhat the multiplication of the pest, 500 puparia were picked from soil under several currant bushes on May 1-2, and were placed in breeding jars under laboratory conditions, but not a single parasite emerged. An examination of nearly 2000 puparia gathered in the spring, showed that some of these were seemingly attacked by some predaceous enemy. As already stated, six small white oval eggs, apparently of a Hymenopterous parasite, were found in the respiratory hole of the fruit fly larva in a Chautauqua gooseberry.

## SPIDERS.

A number of different species of spiders prey upon the adults (Fig. 16, C.). On June 9, 1914, when the fruit flies were noticed especially abundant in shady localities, the remains of four specimens were found in a web on an apple tree and the spider was devouring a fifth fly. A trypetid was also found in a spider's web which was spun on a currant leaf.

## TOADS.

In a commercial currant and gooseberry patch, numerous toads were observed partly buried in the ground during the daytime. It is a well known fact that toads feed principally at night, but they sometimes emerge from their shelter before sundown or after a shower. To determine whether the currant fruit fly is snapped up by toads, it was decided to examine the contents of the alimentary canal of several toads. Accordingly, three toads were captured under gooseberry bushes late in the afternoon on June 19, and two were taken during the morning of June 23, 1914. A single female specimen of *Epochra canadensis* was found in the stomach of one toad captured on June 23. The adult sawfly of the imported currant worm (*Pteronotus ribesii* Scop.) which often strips the foliage of currant and gooseberry bushes, was also found in the digestive canal of a toad. A gooseberry was found in the stomach of one of the toads.

As the toads were collected after the period of emergence of the adults in 1914, it was decided to again examine the con-

tents of the alimentary canal of toads captured during the period that the currant fruit flies issued in 1915, for it was believed that the trypetids which emerged from the soil with wings not expanded, would be devoured in larger numbers by these natural enemies. One toad was caught on June 4, and three on June 7, during the early mornings while hopping about under gooseberry bushes; whereas, two were captured on June 7, and one on June 11, during cloudy afternoons after light showers of the mornings had aroused them to activity. A glance at table 9, shows the number of adults which emerged on the dates that the toads were captured, and table 18, indicates the number of specimens taken in shady localities. Dissections of the toads did not show a single trypetid in any part of the digestive canal.

#### FUNGUS DISEASE.

Ninety fruit flies captured in the field on June 17, 1914, were confined in a breeding jar, and of this number one male died of a fungus disease on the following day. A successful attempt was made to spread this disease to healthy specimens under laboratory conditions. Trypetids were confined with the diseased insect for several hours in a vial plugged with moist cotton. These flies were then transferred to a breeding jar containing about an inch of moist sand. The disease was contracted by a number of the adults. Healthy individuals were now placed in the jar and numerous specimens succumbed to the effects of the fungus. The dead flies were found glued with the end of the proboscis to the sides of the jar, and the legs were usually bent beneath the body. We attempted to remove one of the imagoes from the glass jar by seizing the abdomen with a pair of forceps and gently pulling, but the mouth-parts were glued so tightly to the glass that the body was torn in two parts.

Diseased trypetids were scattered in shady localities of a currant and gooseberry garden. A single fruit fly which died of the fungus, was found attached to a currant leaf (Fig. 16, A.), but this specimen may not have contracted the disease from the dead infected insects introduced in this garden.

An attempt was made to transfer the fungus to other species of fruit flies confined in breeding jars with diseased currant fruit flies. Four sun-flower flies (*Straussia longipennis* Wied.) died of the fungus (Fig. 16, B.) at the end of 10 to 12 days. The

adults of the apple maggot (*Rhagoletis pomonella* Walsh), however, did not contract the disease.

## METHODS OF CONTROL.

### DESTRUCTION OF INFESTED FRUIT.

A measure of control recommended, is to frequently gather fallen infested fruits and burn them. As other writers have already pointed out, this system can not be relied upon to destroy all of the flies, for some of the larvae issue from the fruit before it falls to the ground.

The tedious task of picking up drops presents a number of difficulties. If currant bushes are grown in grass, it is practically impossible to find all of the infested berries. Gooseberry branches heavily laden with fruit, when not propped up, hang close to the ground, and one experience in picking up infested berries will probably be sufficient with most persons not to repeat the performance again, for the thorns scratch and break off in the hands, arms and body. When currants and gooseberries are grown on a commercial scale, the expense of labor for gathering drops would consume most of the profits. Few, if any farmers would have time to practice this means of control.

During the past two seasons, the remedial measure of frequently gathering fallen infested fruit was put to an experimental test in a commercial currant and gooseberry garden under town conditions. Since lack of coöperation of citizens has been shown to defeat horticultural sanitation methods of controlling other species of fruit flies under residential conditions, it was decided to pick up drops not only in the commercial garden but also in adjacent dooryards. Cheese cloth was fastened to the ground below currant bushes in the commercial garden, so that infested berries could be found more easily on a white background. One man was stationed in the field to collect drops daily under favorable weather conditions from the middle of June until the crop was harvested. He was able to pick up all of the fallen fruit at least twice per week. A weekly record of the fallen infested gooseberries obtained in the commercial garden during each season is given in table 20.

TABLE 20.

*Weekly Record of Gooseberry Drops in Commercial Garden.*

1914	qt.	1915	qt.
June 14-20	8	June 13-19	5
June 21-27	42	June 20-26	26
June 28-July 4	12	June 27-July 3	32
July 5-11	26	July 4-10	22
July 12-18	15	July 11-17	16
<hr/>		<hr/>	
103=3 bu. 7 qt.		101=3 bu. 5 qt.	

It is evident from the results recorded in table 20, that the frequent destruction of fallen infested fruit can not be relied upon as a measure of control under town conditions. The explanation may be due partly to the fact that some of the larvae issue from the berries before they fall to the ground. It is evident from certain phases of the work on the life history of the pest, that infested berries must be collected daily. In all probability, currant fruit flies from outside sources invaded the locality in which horticultural sanitation methods were adopted.

One objection may be raised against this experiment due to the fact that 274 marked female currant fruit flies were liberated in the commercial garden, to determine the preoviposition period and longevity of the adults. It must be noted, however, that 220 females emerged in cages in this garden and that these same specimens were marked and released. During the season, 139 unmarked female flies were captured in shady localities of the commercial garden before mating commenced, and 972 unmarked females were caught after egg-laying began as indicated in table 18.

The effect of gathering fallen infested fruit during one season showed a decrease in the number of currant fruit flies which emerged in a cage during the following season. In the spring of 1914, a cage was placed over a white currant bush in the commercial garden and 535 trypetids issued as indicated in table 8. No infested fruit was gathered in the season of 1913, but the drops were picked up at least twice per week in the season of 1914. In the spring of 1915, 180 adults issued in a cage enclosing a white currant bush which was adjacent to the one used in the previous season.

During the picking of the crop one commercial grower, sorted out the maggoty gooseberries. As the harvesting of the crop extends over a period of several weeks, the daily destruction of infested fruit by burning is not always a convenient method. A number of experiments were performed to determine whether a more simple means of destroying infested fruit could not be adopted.

To determine the number of larvae which would pupate when maggoty fruit was submerged in water, infested currants and gooseberries were placed in pans or pails of water. At the end of one, two, three and four days, the fruit was removed from the containers and placed on sand. The figures in table 21, indicate the number of larvae which pupated.

TABLE 21.

*Number of Larvae Which Pupated After Infested Fruit was Submerged in Water for a Period of One to Four Days.*

Quantity of infested fruit	Days submerged in water	Number larvae pupated
<b>Currants</b>		
100	1	15
100	2	8
100	3	0
100	4	0
<b>Gooseberries</b>		
100	1	1
100	2	0
100	3	0
100	4	0
1 qt.	1	45
1 qt.	2	39
1 qt.	3	0
1 qt.	4	0

As all of the maggots in the infested currants and gooseberries used in the previous experiment were immature at the time that the fruit was emersed in water, another experiment was performed to determine the number of mature larvae which would pupate when submerged in pans of water. At the end of one, two, three and four days, 100 maggots were removed from each container and placed on sand. The figures in table 22, show the results.

TABLE 22.

*Number of Mature Larvae Which Pupated After Being Submerged in Water for a Period of One to Four Days.*

Number of larvae	Days submerged in water	Number pupated	Number dead pupae
100	1	95	28
100	2	30	29
100	3	2	2
100	4	0	0

It is evident from these experiments that maggoty fruit or mature larvae when submerged in water for a period of two days failed to give rise to living pupae. Infested currants and gooseberries sorted out during the harvesting of the crop or gathered from the ground could be dumped daily into a pail, barrel or tank of water. The size of the container to be used would depend upon the quantity of drops. When a sufficient amount has accumulated, two days must elapse, after the last addition of infested fruit to the container, before burying or plowing the fruit in the soil.

#### REMOVAL OF SOIL UNDER BUSHES.

A remedial measure frequently recommended is to remove the surface soil to a depth of one to three inches under the bushes and to deposit it on a road or some other exposed place or to bury it deep. These three different methods were put to experimental tests.

In the first experiment the ground was removed from under 12 of 13 currant bushes growing close together in a single row. It was not difficult to work below the shrubs for they were propped up with wooden railings and the earth had been hilled from 7-12 inches above the surrounding substratum. A gardener's trowel was used to scrape off at least three inches of the surface soil, but difficulty was experienced in removing the dirt beneath the net-work of rootlets. Many of the roots were exposed and some were injured. As soon as a sufficient amount of ground had accumulated, it was loaded on a wheel-barrow,

- dumped and spread out on the street. At some distance from the currant bushes, new soil was loaded on the wheel-barrow and replaced around the shrubs. One man removed and replaced the earth in half a day.

The soil spread out on the street was soon converted into dust. Two weeks after the ground was dumped on the street, the dusty soil was transferred into breeding cages in an insect-house. Not a single fly emerged from this material.

A cage, with sides and top made of wire netting used for mosquito screen, was placed over the thirteenth currant bush. On May 15, 1915, the soil within the cage was treated with one part of carbolic acid emulsion to fifty parts of water at the rate of one-half gallon per square foot. On May 29, a number of currant fruit flies were found in the cage and a second application of the formula was given. A few specimens of this insect continued to emerge until June 11.

The currants were examined from time to time and it required a search to find a maggoty fruit, even though the infested prematurely ripened red berries are very conspicuous in the bunches of green currants. It must be noted, however, that no data could be obtained as to the infestation of the currants during previous years. Twenty-one quarts of currants were picked from the 13 bushes. This short crop was probably due to the fact that the bushes had been neglected for years, and all of the old wood and also branches containing borers had been pruned. The shrubs were not isolated, for in one of the dooryards at a distance of about 200 feet, were currant and gooseberry bushes with practically all of the fruit infested.

Another method of control suggested as already stated was to remove and deposit the surface soil around currant and gooseberry bushes in some exposed place. In the second experiment 50 puparia were exposed to the sunshine on the surface of the ground below a cage on May 8, 1914. Fourteen adults emerged from May 25-June 6, under these conditions.

In the removal of the dirt under the bushes, one method suggested, as already mentioned, was to deeply bury this soil. A third experiment was performed to determine the distance that the fruit flies upon issuing from puparia, are able to burrow through ground under field conditions. Holes, one-half, one, two, and three feet deep were dug in clay soil. Fifty puparia

were put at the bottom of all of the holes, except the hole three feet deep, in which 100 puparia were placed. The insects were ready to emerge from these puparia, for some of the adults had already issued in the breeding jars a few days before burying them. Clay was tramped into the holes one-half and one foot deep. Another hole one foot deep, was filled with loose wet clay, while loose dry clay was placed in the pit two feet deep. The hole three feet deep was filled with large lumps of clay. Directly over the filled holes cages were placed, so as to capture any flies which would burrow through the earth. Not a single specimen was found in any of the cages. The clay became hard and compact due to rains, and the surface soil baked into a hard crust, and these conditions probably prevented the imagoes from burrowing completely through the ground. It should not be assumed, however, from this experiment that the pest would not be able to burrow through other kinds of soil. We (1914, pp. 198-199; 1915, pp. 78-83) found that other species of Trypetidae worked their way through two feet of filled earth and four feet of dry sand.

#### SIFTING PUPARIA FROM SOIL.

An attempt was made to sift the puparia from the soil under four currant bushes instead of removing and replacing the ground. The earth was first sifted through a one-quarter inch mesh wire netting, so as to break up the lumps and to remove the roots and grass, then as much of this soil as possible was passed through a mosquito wire. The dirt which failed to pass through the mosquito wire sieve, was spread on white paper in the laboratory and 1927 puparia were counted. After removing as many puparia as could be found, the ground was placed in breeding cages in the insect-house and 60 male and 57 female fruit flies emerged from May 16-28. A cage was placed over one of the currant bushes and 221 adults,—114 males and 107 females—issued from May 25-June 11. It was discovered later that the smaller puparia pass through the meshes of the mosquito wire and this gives a reasonable explanation for the emergence of the 221 specimens in the cage. Sifting the soil through wire netting with meshes smaller than screen wire would be an exceedingly laborious task.

## STIRRING THE SOIL.

To determine, what effect stirring the ground would have on the pupae, 50 puparia were placed in clay soil, which had been previously loosened to a depth of three inches under a cage. Several times a week, the clay was stirred with a rake. Nine fruit flies emerged from May 25-June 3.

## EFFECT OF CHEMICALS ON OR IN SOIL.

It is claimed that "as the larvae find fine dry dusty substances prejudicial to their transformation a heavy dressing of coal ashes placed under the bushes in June would destroy many of the larvae\*\*\*." One hundred maggots after issuing from currants were dropped into a jar containing six inches of sifted wood ashes. Several weeks later 61 perfectly formed puparia were counted and 39 dead pupae and shriveled larvae were found in the ashes. Under field conditions the maggots probably would have burrowed through the ashes and entered the ground to pupate, and it is questionable whether the death rate would have been as high as in the jar of ashes.

One farmer had placed coal and wood ashes on the ground below currant and gooseberry bushes for several years each spring and the ashes had formed a hard crust. An examination of the crop, however, showed the presence of maggoty fruit, but the infestation was not so severe as in the case of currant and gooseberry bushes which had not been treated in this manner situated in dooryards about 315-565 feet distant. In the following season, 26 trypetids issued from May 27-June 2, in 5 ground cages covering 11 square feet of ashes which had been hoed below white currant bushes. A ground cage, two feet square, was placed over compact ashes between two gooseberry bushes, but not an adult was found in the cage during the season.

A method to control the Mediterranean fruit fly suggested in Malta in 1889, was to strew "the surface of the ground with one part of sulphate of iron to 24 parts of sand, the ground to be subsequently watered." In our experiment one quart of infested gooseberries was placed on the surface of one part of finely-powdered sulphate of iron mixed with 24 parts of sand, the mixture being subsequently watered. Several weeks later,

the mixture was sifted, and six perfectly formed puparia and three shriveled and discolored puparia were found.

Three experiments were performed to ascertain the effect of lime on the larvae in gooseberries. The details are given in table 23.

TABLE 23.

*Effect of Lime on Larvae.*

Quantity of infested gooseberries	Quantity of lime to two square feet of soil	Number larvae pupated	Number of dead pupae
1 qt.	5 lb. unslaked, stirred in soil	22	7
1 qt.	15 lb. unslaked, on berries	76	13
1 qt.	10 lb. slaked, on berries	61	20

A number of preliminary experiments were performed with other chemicals placed on or in ground to ascertain their effect on pupae buried three inches below the surface of clay soil and possibly on the adults upon emerging. The area of land treated varied from one and one-half to two or three square feet. Immediately after the application of the chemical, cages with top of screen wire and board sides, were placed over the areas treated. Earth was banked and tamped around the bottom of each cage to prevent the escape of any of the flies. Some of the pupae were probably not killed by the chemicals, but the flies undoubtedly were not able to burrow completely through the clay soil, for this had become hard and compact and the surface was baked into a hard crust. It was impossible to make a daily visit to these cages, and the records in table 24, of the number of flies which emerged are not complete, for the wings of dead flies devoured by Carabids and ants were found under the cages.

TABLE 24.

*Chemicals on or in Soil and Their Effect on Pupae and Adults Upon Emerging.*

Square feet of soil treated	Number of puparia buried	Dates of application	Treatment	Number of adults emerged
2	50	May 11	1 lb. sulphate of iron mixed with 24 lb. of sand on soil	5
2	25	11	5 lb. unslaked lime stirred in soil	5
2	25	11	15 lb. unslaked lime on soil	1
2	25	11	10 lb. lime slaked on soil	2
2	50	12	1/4 lb. potassium cyanide in soil	0
2	50	13	4 tablespoons carbon bisulphide in soil	16
2	50	12, 22	2 gal. 1 pt. formaldehyde to 30 gal. water	14
1 1/2	25	11, 22	1 1/2 gal. 2 pt. formaldehyde to 50 gal. water	9
1 1/2	25	12, 22	1 1/2 gal. 1 part Nikoteen to 100 parts water	2
1 1/2	25	12, 22	1 1/2 gal. 1 part Nikoteen to 400 parts of water	2
1 1/2	25	13, 22	1 1/2 gal. 1 part Black Leaf 40 to 600 parts water	0
1 1/2	50	13, 22	1 1/2 gal. 1 part Black Leaf 40 to 800 parts water	6
1 1/2	50	12, 22	1 1/2 gal. 1 part stock solution kerosene emulsion to 12 parts water	0
1 1/2	25	12, 22	1 1/2 gal. 1 part stock solution kerosene emulsion to 20 parts water	1
2	50	11, 22	2 gal. 1 part stock solution carbolic acid emulsion to 35 parts water	1
2	50	12, 22	2 gal. 1 part stock solution carbolic acid emulsion to 50 parts water	0
1 1/2	25	11	None (check)	12

In view of the fact that no adults emerged from 50 puparia buried with potassium cyanide as indicated in table 24, a number of experiments were now conducted to determine the effect of potassium cyanide on wild gooseberry bushes growing in sod and on cultivated currant bushes. Different quantities of this poison were buried in holes three inches deep at various distances from the origin of the branches above the soil as indicated in table 25. Several weeks after the treatment, all of the wild gooseberry and cultivated currant bushes had shed their leaves, but the next spring all of the shrubs "leafed out" again.

TABLE 25.

*Quantity of Potassium Cyanide Buried in Soil at Various Distances from Bushes.*

Quantity of potassium cyanide (oz.)	Number of holes, poison was buried	Distance from bush poison was buried (inches)	Kind of bush
1	4	6	Wild gooseberry
2	6	4	Wild gooseberry
3	8	8	Wild gooseberry
4	8	12	Wild gooseberry
4	8	18	Red currant

No fruit flies emerged from 50 puparia buried in clay soil treated with two applications of one part carbolic emulsion to 50 parts of water, at the rate of one-half gallon per square foot; but in the experiment previously described in which a cage was placed over a currant bush and the ground was treated with the same formula, flies emerged after each application of the insecticide.

USE OF OILS TO TRAP ADULTS.

Recent investigations have shown that certain vegetable and petroleum oils attract enormous numbers of male fruit flies of different species. Pans containing pure oil or a few drops of oil poured in water which partly filled the pans were placed upon the ground under currant and gooseberry bushes. Each oil was tested out separately so that there was no possibility of the volatile parts of different oils interfering with one another. The number of pans used, the number of days each oil was tested and the results obtained are stated in table 26.

TABLE 26.

*Number of Male and Female Currant Fruit Flies Captured in Oils.*

Oils	Pans	Days	♂	♀
Aniline	1	14	0	0
Balsam (Guryeen)	4	9	0	0
Bay leaves	2	13	1	0
Bergamot	3	17	0	1
Cajeput	1	13	0	0
Camphor	5	10	1	0
Caraway	5	4	0	0
Castor	1	14	0	0
Cedar	1	14	0	0
Celery seed	1	14	0	0
Clove	1	14	0	0
Cinnamon (Cassia)	4	3	0	0
Citronella	3	9	1	2
Cubarb	1	13	0	0
Cumin	2	13	0	0
Eugenol	3	7	0	0
Hemlock	4	3	0	0
Horsemint	5	10	0	1
Isoeugenol	3	7	0	0
Juniper (Savin)	4	10	0	1
Kerosene	7	11	1	5
Kuromoji from Japan	4	3	0	0
Lavender	3	13	0	0
Marjoram	1	13	0	0
Methyleugenol	3	7	0	0
Origanum	1	13	0	0
Paraffin	1	14	0	1
Peppermint	3	7	0	1
Phenolpthaline	1	13	0	0
Pine (Turpentine)	1	14	0	0
Pycnischennum lanceolatum	5	4	1	0
Sassafras	6	10	0	0
Spearmint	7	3	1	0
Tansy	3	13	0	0
Thyme (red)	4	9	0	0
Thyme (white)	3	17	0	0
			6	11

In all probability, the currant fruit flies that were found in the pans were not attracted to these oils but came within the sphere of influence by accident, became stupefied and dropped into the oils.

## FOWLS.

It is claimed that fowls, when allowed to run at large under currant and gooseberry bushes, will destroy many larvae and puparia. One grower who had tried this method raised the objection that the hens scratched large holes below the bushes and exposed the roots. He also stated that the hens ate the fruit from the lower parts of the bushes. To determine whether

fowls relished the berries, hens were called together at their regular feeding time, and a quart of ripe red and white currants and gooseberries were thrown on the ground. The flock of hens tasted the fruit and seemed to prefer the currants but they soon departed leaving some of the currants and most of the gooseberries on the ground. To avoid loss of fruit, fowls could be placed in the berry patch after the crop is harvested and in early spring before the fruit is set.

Hens were fed on currant fruit fly puparia to determine whether any pupæ would survive after having been taken into the digestive canal. A caged hen with an empty crop was offered 200 puparia and in 15 minutes she discovered the puparia and swallowed all of those that rested on the surface of the sandy soil. An hour later another 100 puparia were thrown into the cage and in a few minutes she began to feed on these. After the fowl had remained in the cage for two hours, she was dissected, and the contents of the alimentary canal were examined. Four puparia were found in the oesophagus, 6 in the stomach, 71 in the crop and 8 in the gizzard. Of the total number of puparia found in the oesophagus, stomach and crop, 12 had been injured by the bill. Seven puparia had been found up in the gizzard, but one was intact.

As none of the puparia had reached the intestine in the previous experiment, 200 currant fruit fly puparia were placed at the rate of 50 at intervals of an hour, into the mouth of a hen with an empty crop. Six hours after the first lot of puparia had been fed to the fowl she was dissected, and it was found that the puparia had been converted into a paste-like substance in the intestine. It is evident that no currant fruit fly puparium can pass through the digestive canal of fowls and issue as flies.

#### LATE PICKING TO AVOID MAGGOTY FRUIT.

One person picked his crop of currants and gooseberries late in the season to avoid maggoty fruit. From time to time currants and gooseberries with egg punctures were picked from his bushes and the last larvae issued on July 30, from the former and July 28, from the latter. During the previous year out records show that the last maggot emerged on July 29. To determine whether any larvae would issue later in other localities of Orono, one pint of currants and three quarts of goose-

berries were picked from bushes on July 30, in the commercial garden but not a single maggot bored out of the fruit. In one garden where currants were so badly infested that the crop was not harvested, all fruit still adhering to the bushes and also drops were gathered on July 30, but no larvae emerged. If picking could be delayed until August 1, practically all fruit which remains on the bushes would be free from maggots. In 1914, the commercial grower picked his crop from July 14-23, and in 1915, from July 19-28. If late picking is adopted, the danger of losing some of the sound fruit through sun scald must be taken into consideration.

#### Poisoned Bait Spray.

Lovett (1911-'12, pp. 135-136) attempted to control the currant fruit fly with the poisoned bait spray in Oregon, using a formula which Mally (1909, p. 6) employed to combat the Mediterranean fruit fly in South Africa. No conclusive results were obtained, but the following brief summary of the season's trials is given:

"1. The sweetened poison does attract the fly, *Epochra canadensis*."

2. Frequent rains during the period of experimentation made numerous applications necessary.

3. Granulated sugar is rather expensive; it crystallizes quickly and is not so satisfactory as a cheaper brown sugar would probably be."

4. The crop was injured one-half in many localities and in a few cases the fruit, due to the maggot's attack, was not worth gathering."

5. It is not considered that the amount of poison which would incidentally fall on the fruit is sufficient to endanger human life. The foliage spray is more effective for the flies."

The effectiveness of different kinds and amounts of poisons added to diluted molasses was tested on fruit flies confined in cages enclosing currant or gooseberry bushes in the field. After the poisoned bait had been applied to the bush with a bucket pump provided with a Bordeaux nozzle, 50 or more trypetids were liberated in the cage. The ground below each bush was covered with cheese cloth, so that the flies which succumbed to the effects of the poison could be found more easily on a

white back ground. The results with each formula of the poisoned bait used in the various experiments are given in detail as follows:

In the first experiment we endeavored to determine what effect arsenate of lead (paste) without molasses would have on the pest. After a light application of the spray was made to the foliage of a gooseberry bush, 50 fruit flies were liberated in the cage. Many of the specimens rested on the sides and top of the cage. The formula employed and the daily death rate of the flies are given in table 27.

TABLE 27.

*Death Rate of Adults Confined in Cages Enclosing Gooseberry Bushes Sprayed With Arsenate of Lead or Poisoned Bait.*

Molasses (pt.)	Arsenate of Lead (oz.)	Water (gal.)	Death Rate of Flies					Days
			1	2	3	5		
$\frac{1}{2}$	1	1	1	7	3			Flies
$\frac{1}{2}$	1	1	14	12	3	1		Flies
$\frac{1}{2}$	2	1	19	5	8			Flies

As ants were found in the cage devouring and carrying away dead fruit flies, the daily record of the death rate is probably not correct. Living flies were found within the cage at the end of 5 days, when the experiment was discontinued.

To determine whether the fruit fly would feed on arsenate of lead after the water had evaporated, a twig was cut from the sprayed bush, three days after the application of the insecticide, and the stem was emersed in a bottle of water within a glass jar. One fly died at the end of one day, but 24 specimens were still alive at the end of 6 days, when the experiment was discontinued. During the 6 days the cheese cloth covering the top of the jar was moistened with diluted corn syrup and water, several times a day. It was evident that arsenate of lead when dry on the leaves had no marked effect on the fruit flies in captivity under laboratory conditions.

In the next two experiments different quantities of arsenate of lead were added to diluted molasses and the different formulas of the poisoned bait were then tested under field conditions. To prevent the ants from entering the cages through the mos-

quito wire, a layer of pyrethrum was placed on the ground around the bottom of the cages, and kerosene oil was poured on the soil outside of the layer of pyrethrum. Table 27, shows the results with each formula.

It was found that ants were coming into the cages around the base of the branches which the cheese cloth did not cover. Besides the dead trypetids which were devoured or carried away by ants, there were others which did not drop on the cheese cloth. Some of the poisoned flies fell between the branches, then worked their way under the cheese cloth and died, others died on the leaves. The daily record of the death rate of the fruit flies is therefore, not complete.

Small quantities of sodium arsenite added to diluted molasses were tested under field conditions. As many of the fruit flies rested on the sides and top of the cages in the previous experiments, it was decided in this test to spray the remedy through the mosquito wire of the cages on to the foliage of the enclosed currant and gooseberry bushes. Table 28, indicates the results obtained.

TABLE 28.

*Death Rate of Adults Confined in Cages Enclosing Bushes Sprayed With Sodium Arsenite in Diluted Molasses.*

Molasses (pt.)	Sodium Arsenite (gr.)	Water (gal.)	Death Rate of Flies			
			8 hours	1	2	Days
½	2	1	9 flies 29 flies	4 3	16	Flies Flies
½	1	1				

Too much emphasis, however, should not be attributed to any of the experiments carried on under field conditions, because the fruit flies were in captivity and in feeding were forced to consume the poisoned bait. Again, some of the trypetids may have died due to the exposure to sunshine and not to the effect of the poison.

Three currant bushes not enclosed in cages were sprayed with the poisoned sweet, using one gram of sodium arsenite, one-half pint of molasses and one gallon of water. Cheese cloth was spread on the ground below the bushes, but not a single

dead fruit fly was found. The leaves showed no evidence of burning.

An experiment was performed in the field to compare the attraction of the adult for the poisoned bait applied to the lower branches of a red currant bush with honey-dew of plant lice present on the foliage. On June 22, the lower branches of the currant bush were baited, and then 100 male currant fruit flies were liberated in a cage enclosing the bush. A week later, a few typetids were found alive in the cage and at the end of two weeks a single specimen was still alive.

In 1914, the poisoned bait spray was tested in a commercial currant and gooseberry garden consisting of 100 bushes. This garden was not isolated, for currant and gooseberry bushes were present not only in three adjacent dooryards but also in other yards in the vicinity. To isolate this commercial garden as much as possible, it was decided to spray all of the currant and gooseberry bushes found in this locality. A total of 142 bushes consisting of 18 currant and 124 gooseberry bushes were sprayed; these were distributed in 8 different gardens. This entire area had a natural isolation on three sides,—by the Stillwater and Penobscot Rivers and by a bay of the Penobscot.

Inquiry was made as to the infestation of the currants and gooseberries during previous years. Some of the owners stated that in some years practically all of the fruit had dropped to the ground, but in other years the infestation was not so severe and only about one-half of the crop was lost. The most reliable data were obtained from the commercial grower, who kept a record of the yield of the currant and gooseberry bushes during the previous five years (Table 30). No attempt had been made by any of the gardeners to control the fruit fly and all of the infested drops had been allowed to remain on the ground in prior years.

In order to avoid any complication of results, it was decided that none of the gardeners were to use their remedial measures against the imported currant worm (*Pteronotus ribesii* Scop.). On May 26, we sprayed the foliage of the 142 currant and gooseberry bushes by using 30 gallons of water mixed with 30 ounces of arsenate of lead (paste).

Throughout the season the same formula of the poisoned bait was sprayed on the foliage of 100 bushes in the commercial

garden and on 33 bushes in six dooryards, but on 9 bushes in one garden the same amount of arsenate of lead mixed with water without the molasses was used. The insecticide was applied with a bucket pump, provided with a Bordeaux nozzle. The following proportions of the ingredients were used:

Molasses	½ pt.
Arsenate of lead (paste)	2 oz.
Water	1 gal.

Eight applications of the poisoned bait were made during the season. After a rain and as soon as the weather became settled, the insecticide was renewed. The number of gallons of the poisoned sweet used in each application of the spray on 100 bushes in the commercial garden, on 33 bushes in the six neighboring dooryards and on 9 bushes in the garden treated with arsenate of lead without molasses is shown in table 29. The data on the precipitation were copied from the weather bureau reports taken at the University of Maine.

TABLE 29.

*Quantity of Poisoned Bait Used, Dates of Applications of Spray and Weather Records.*

Quantity of poisoned bait		Commercial garden 100 bushes (gal.)	Six gardens 33 bushes (gal.)	One garden 9 bushes (qt.)	Dates of applica-tions of spray	Days spray remained on bushes with-out rain	Dates of rainfall	Precipi-tation
Commercial garden 100 bushes (gal.)	Six gardens 33 bushes (gal.)							
6	3	2	May 29	1	May 30	—	—	—
3	2	2	June 2	2	June 1	.11	—	—
6	3	2	5	—	4	.31	—	—
3	2	2	6	1	5	1.20	—	—
4	3	2	10	—	7	—	—	—
3	2	2	13	—	8	.14	—	—
3	2	2	18	—	10	.10	—	—
3	2	2	15	—	12	—	—	—
3	2	2	16	—	13	—	—	—
3	2	2	17	2	15	—	—	—
3	2	2	19	—	16	.96	—	—
3	2	2	20	—	19	—	—	—
31	19	16	22	7	20	.55	—	—
				13	29	.34	—	—

— Indicates a trace of rain.

After four applications of the spray had been made, it was found that many fruit flies sought shady localities in the neighborhood of the currant and gooseberry bushes. Male and female flies were found in the shade, at a distance of about 200 feet from their breeding grounds. As soon as we became acquainted with this habit of the pest in the field, it was decided to spray the vegetation and shady places adjacent to the commercial garden. Apple and poplar trees, raspberry and blackberry bushes and truck crops were treated with the same formula of the poisoned bait as was used on the currant and gooseberry bushes. Three gallons were used in each application on June 10, 13, 17 and 22. Grass, fence posts, scantlings, a wood pile, in fact, all shady places wherever the trypetid was found, were sprayed on the above dates with three gallons in each application of the following formula:

Molasses	$\frac{1}{2}$ pt.
Sodium arsenate	1 oz.
Water	1 gal.

A record of the crop harvested in the commercial garden in the seasons of 1909-1913, without control measures, compared the yield in 1914, after spraying, is shown in table 30. It must be noted, however, that two of the nine currant bushes were enclosed by cages in the season of 1914, thus protecting the fruit from the attacks of the pest, and hence increasing the yield of the crop. This table also shows the crop harvested in 1914-1915, after picking up fallen infested fruit during the two seasons, compared with the yield in 1916, when no remedial measures were used. A weekly record of the gooseberry drops gathered in the commercial garden during the seasons of 1914-1915, is given in table 20.

TABLE 30.

*Record of Crop Harvested in 1909-1916, in Commercial Garden.*

Year	Gooseberries		Currants	Method of control
	bu.	qt.		
1909	22		35	None
1910	12	3	0	None
1911	8	7	2	None
1912	8	27	26	None
1913	12	2	12	None
1914	10	1	17	Poisoned bait spray; destruction of fallen infested fruit
1915	16	0	8	Destruction of fallen infested fruit
1916	7	6	2	None

To check up the effectiveness of the poisoned bait spray, all of the gooseberry drops were gathered from the ground. A weekly record of the fallen infested gooseberries in the commercial garden in 1914, is given in table 20. As the drops during the first three weeks were not full grown, the actual loss is greater than the number of quarts recorded in table 20. The berries were ripe during the fifth week and the owner began to pick his crop on July 14.

The results of the season's spraying in the commercial garden and the three neighboring dooryards compared with the infestation of gooseberries on two untreated bushes used as a check at a distance of about 2000 feet from the commercial garden, are indicated in table 31. No record was taken of the infestation of currants.

TABLE 31.

*Results of Season's Spraying in 1914.*

Number of gooseberry bushes sprayed	Non-infested gooseberries qt.	Gooseberry drops qt.	Infested gooseberries %	Check infested gooseberries %
				%
91	321	103	24	100
3	7	5	41	100
8	4	5	55	100
7	5	9	64	100

In three gardens the gooseberry drops were not gathered because the bushes were growing in high grass. As these bushes had been neglected for years the yield of fruit was very low.

The seven currant and two gooseberry bushes treated with arsenate of lead without diluted molasses resulted in a total loss of all of the gooseberries and only four quarts of currants were picked.

After the bushes had received 7 applications of the poisoned bait spray, some of the currant and gooseberry leaves began to show evidence of spray injury on June 20. Some of the leaves turned yellow, speckled with small brown areas (Fig. 15, H) and later dropped from the bushes. On the other hand, the currant and gooseberry bushes sprayed on the same dates with arsenate of lead mixed with water without diluted molasses, showed no evidence of spray injury.

The following formula of the poisoned bait spray with the use of a so-called "quick killing di-plumbic arsenate of lead" burned the foliage of currant and gooseberry bushes so that many of the leaves turned yellow and dropped:

Arsenate of lead	3 oz.
Molasses	1 gal.
Water	2 gal.

The cost of the insecticide for eight applications of the spray to 100 bushes not including labor amounted to \$.65. The additional cost of four applications of the bait to the vegetation surrounding the commercial garden and to the shady localities amounted to \$.46.

There was some evidence to show that the fruit fly was attracted to the poisoned bait. During the application of the spray an occasional trypetid was observed feeding on the bait which was spattered on the outside of the bucket. In a number of instances, after reaching down to the bottom of the bucket to determine whether the arsenate of lead was in suspension and upon withdrawing the hand, a specimen alighted on the arm to feed on the poisoned liquid.

In the season of 1915, the poisoned bait spray was tested in a currant and gooseberry patch located on a farm. Twenty-two gooseberry bushes were in an orchard and 13 currant bushes

were situated along the margin of a vegetable garden. At a distance of about 315-565 feet from this farm, currant and gooseberry bushes were present in 5 door-yards.

The farmer informed us that the bushes had been growing in the same place for a period of 15 years, and that in some years he had lost about one-half of his crop due to insect pests. As a remedial measure during a number of years, he had placed coal and wood ashes on the surface of the ground under the bushes. The ashes had formed a hard crust under some of the gooseberry bushes.

On May 25, the foliage of the currant and gooseberry bushes were sprayed with two gallons of water mixed with two ounces of arsenate of lead (paste) to control the imported currant worm (*Pteronotus ribesii* Scop.).

The proportions of the ingredients of a poisoned bait spray recommended by Winter (1913, p. 11) to control the Mediterranean fruit fly in Bermuda, was used in our work, but sodium arsenite was substituted for arsenate of lead. The following formula was used:

Molasses	2 qts.
Sodium arsenite	1 oz. (dissolved in 1 qt. of boiling water).
Water	1 gal.

The poisoned bait was applied to the lower branches of the currant and gooseberry bushes and to the grass under the bushes with a bucket pump, while the upper branches were baited with a paint brush. The trunk and lower limbs of the fruit trees near the gooseberry bushes were also sprayed.

Four baitings were made during the season. Table 32, shows the quantity of insecticide used, the dates of applications of the spray and data on precipitation:

TABLE 32.

*Quantity of Poisoned Bait Used, Dates of Application of Spray and Data on Precipitation.*

Quantity of poisoned bait (gal.)	Dates of applications of spray	Days spray remained on bushes without rain	Dates of rainfall	Precipitation
8	May 29	8	June 7 8 10 11 12 15 17 18 20 23 24 26 27 28 29 30 July 1 2 3	.04 .87 .10 .16 .30 .03 .65 .06 .07 — — .15 — .04 .35 .03 .11 .61 .32 4.00
3	June 12	0		
3	21	2		
3	July 3	2		
12		12		

— Indicates a trace of rain.

In checking up the effectiveness of the poisoned bait spray all of the gooseberry drops were gathered from June 13-July 14, below two baited bushes and also under two check or control gooseberry bushes located at a distance of 525 feet. A baited and check gooseberry bush were growing in the shade of apple trees and the other two were situated in the sunshine. On July 14, all of the gooseberries from the four bushes were picked. Table 33, shows the results:

TABLE 33.

*Infested Fruit on Baited and Check Gooseberry Bushes Including Drops in 1915.*

Baited bush in shade	Baited bush in sunshine	Check bush in shade	Check bush in sunshine
33%	17%	79%	23%

The cost of the insecticide for four applications of the spray to 33 bushes not including labor amounted to \$.575.

### ARE HONEY BEES POISONED?

A serious objection to the adoption of the fruit fly remedy would be the poisoning of the honey bees. Honey bees visit the currant and gooseberry blossoms in enormous numbers and if the bushes were sprayed during the flowering period there is a possibility that the bees may be poisoned through feeding in spray-poisoned blossoms. The first application of the spray, however, was applied after the maximum period of emergence of the currant fruit fly had commenced, at the time when all of the gooseberries and most of the currants had set.

Are honey bees attracted to the poisoned diluted molasses applied to currant and gooseberry bushes after all of the fruit is set? On June 22, 1914, one hundred currant and gooseberry bushes in the commercial garden were baited, when honey bees were visiting the flowers of raspberry and blackberry bushes in large numbers. The raspberry and blackberry bushes were growing between or near the currant and gooseberry bushes. An entire day was spent in watching the honey bees, but the bees paid no attention to the film of poisoned sweet on the leaves. The next morning the raspberry and blackberry bushes were sprayed and a half day's observation failed to show that a single bee deserted the flowers for the poisoned diluted black strap molasses.

### SUMMARY.

A summary of the different methods of control is herewith given:

The destruction of fallen infested fruit can not be advocated as a method of control in commercial currant and gooseberry gardens, for the expense of labor employed in gathering the drops would consume most of the profits. Fallen infested berries must be gathered daily. This system can not be relied upon to destroy all of the flies, as some of the larvae issue from the fruit before it falls to the ground.

The daily destruction of all infested fruit by burning or boiling is not always a convenient method and is somewhat

expensive on account of the kerosene and fuel consumed. Submerging fruit in water for a period of two days will destroy all of the larvae. When a sufficient amount of submerged fruit has accumulated, two days must elapse after the last addition of infested fruit to the container has been made before burying or plowing it in the soil.

In view of the fact that the pest winters over in the pupa stage in the ground below currant and gooseberry bushes, the removal of the surface soil to a depth of three inches, dumping and spreading it out on the road destroys the pupae. The soil must be carefully removed below the network of rootlets. New soil at some distance away from the bushes should replace that removed. Few infested fruits were found in the currant patch thus treated but it must be noted, however, that no data could be obtained as to the infestation during previous years in this garden.

Sifting the puparia from the soil instead of removing and replacing the ground under the bushes proved to be an unsatisfactory method. The earth was first sifted through a one-quarter inch mesh wire netting, so as to break up the lumps and to remove the roots and grass, then as much of the soil as possible was passed through a mosquito wire. It was found that the smaller puparia passed through the meshes of the mosquito wire. Sifting the soil through wire netting with meshes smaller than screen wire would be an exceedingly laborious task.

Stirring the soil with a rake several times a week during the spring so as to expose the puparia to the natural enemies and sunshine did not prevent the emergence of some of the flies.

For several years each spring a farmer had placed coal and wood ashes upon the surface of the soil below currant and gooseberry bushes. Currant fruit flies issued in cages placed over hoed ashes but none emerged from compact ashes. An examination of the crop showed the presence of maggoty fruit but the infestation was not so severe as in currant and gooseberry gardens situated at a distance of 315-565 feet.

Various proportions of the following chemicals placed on or in the ground to destroy the larvae, pupae or adults upon emerging, did not give promising results as a method of control: sulphate of iron; unslaked lime stirred in soil; unslaked lime on infested berries or on soil; lime slaked on infested fruit or on

soil; carbon bisulphide; formaldehyde; Nikoteen; Black Leaf 40; kerosene emulsion and carbolic acid emulsion. No adults emerged when various quantities of potassium cyanide was added to soil containing puparia but defoliation resulted.

The currant fruit fly was not attracted to vegetable and petroleum oils used in traps.

Fowls when allowed to run at large under currant and gooseberry bushes, are said to destroy many puparia. To avoid loss of fruit, fowls should be placed in the berry patch after the crop is harvested and in early spring before the fruit is set. An objection raised against this method, is the fact, that the hens scratch large holes below the bushes and expose the roots. No puparia can pass through the digestive canal of fowls and issue as flies.

If the picking of the crop is delayed until August 1, at Orono, Maine, practically all fruit which remains on the bushes would be free from maggots. If late picking is adopted, the danger of losing some of the sound fruit through sun scald must be taken into consideration.

In 1914, the results of spraying the foliage with arsenate of lead added to diluted molasses showed a loss of 24 per cent of the crop of gooseberries in a commercial garden consisting of 100 currant and gooseberry bushes. In three adjacent dooryards 41, 55 and 64 per cent of the gooseberries were infested. The cost of the insecticide for 8 applications of the spray to 100 bushes not including labor amounted to \$.65.

In 1915, a baited gooseberry bush growing in the shade showed a loss of 33 per cent of the berries compared with 79 per cent of infested fruit on the check or control bush similarly located while a treated and untreated gooseberry bush in the sunshine showed an infestation of 17 per cent and 29 per cent respectively. The poisoned bait, consisting of sodium arsenite and diluted molasses, was applied to the lower branches of the bushes with a bucket pump, while the upper branches were baited with a paint brush. The cost of four baitings applied to 35 currant and gooseberry bushes without labor amounted to \$.575.

If currant and gooseberry bushes are sprayed during the flowering period there is a possibility that the bees may be poisoned through feeding in spray-poisoned blossoms. The first application of the spray, however, should be made at a time

when all of the gooseberries and most of the currants are set. Not a single honey bee was ever observed feeding on the poisoned bait, sprayed on the foliage or branches after the flowering period.

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## EXPLANATION OF FIGURES.

Figure 13 A. Larva eating its way into a currant seed. The head region is buried in the seed and the caudal part is protruding.

B. Mature larva with its body arched in a circle in preparation for a jump. The posterior spiracles are invaginated while the pair of hooked mandibles are attached to a fold at the lower end of the body.

C. The curled body of the larva leans back as far as possible just previous to jumping.

D. R, respiratory pore in peel of currant. E, exit hole of larva.

F. Larva embedded within three currant seeds.

G. Mandibles of mature larva.

H. Ovipositor of *Epochra canadensis* showing tactile bristles.

Figure 14 A. Gooseberry with one egg chamber.

B. Gooseberry with two egg receptacles.

C. Gooseberry with three egg punctures.

D. Tunnel of recently hatched larva beneath the peel.  
E. External indication of decay of gooseberry infested with a currant fruit fly larva.

F. Internal indication of decay of gooseberry. The larva has devoured some of the seeds and pulp.

G. Mature larva boring out of a gooseberry.

H. Exit hole after the larva has emerged from a gooseberry.

I. Gooseberry which has become dried and shriveled after the larva issued.

Figure 15 A. Two eggs deposited in a green currant which shows premature ripening around the egg chambers.

B. Green currant showing premature ripened area two days after oviposition.

C. Two egg punctures in a currant.

D. and E. External indications of decay of infested currants.

F. Mature larva issuing from a currant.

G. Exit hole after larva emerged from a currant.

H. Poisoned bait spray injury to one-half of a gooseberry leaf.

Figure 16 A. Currant fruit fly which died on a currant leaf due to a fungus disease.

B. Male and female sun-flower trypetids (*Straussia longipennis* Wied.) which contracted the fungus from diseased currant fruit flies.

C. Spider which captured a currant fruit fly.

Figure 17, A to E.—Behavior of adults.

F.—Currant fruit fly ovipositing in a currant.

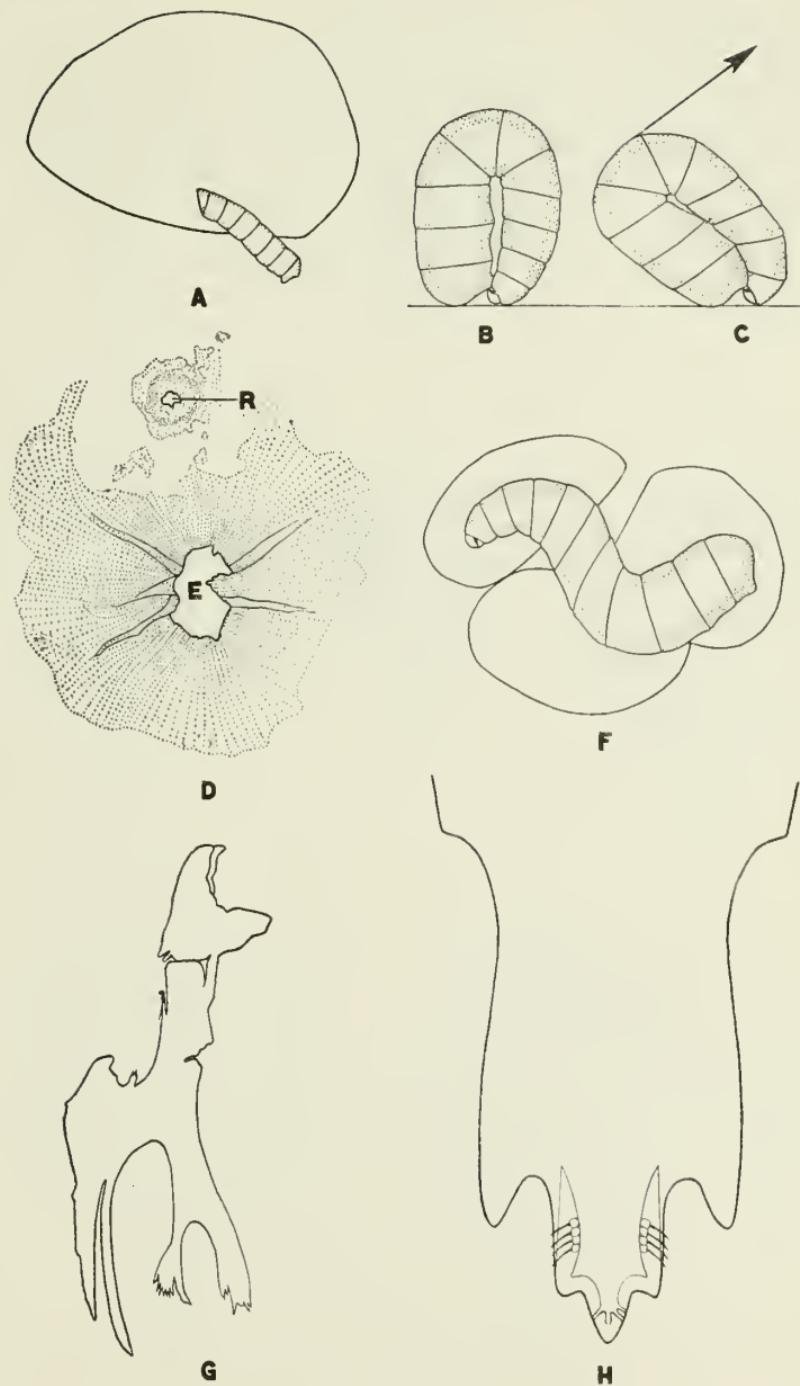


Figure 13.



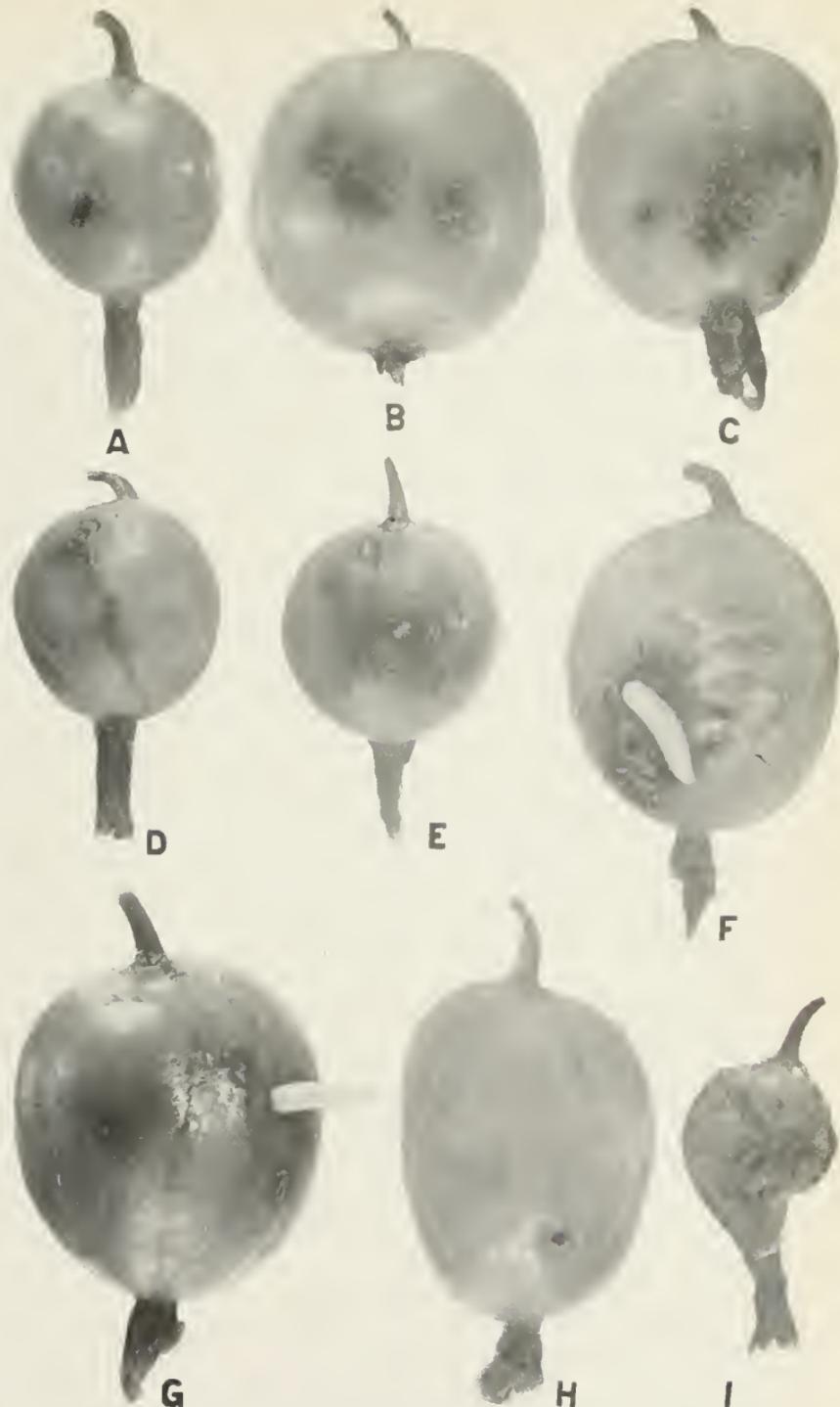


Figure 14.



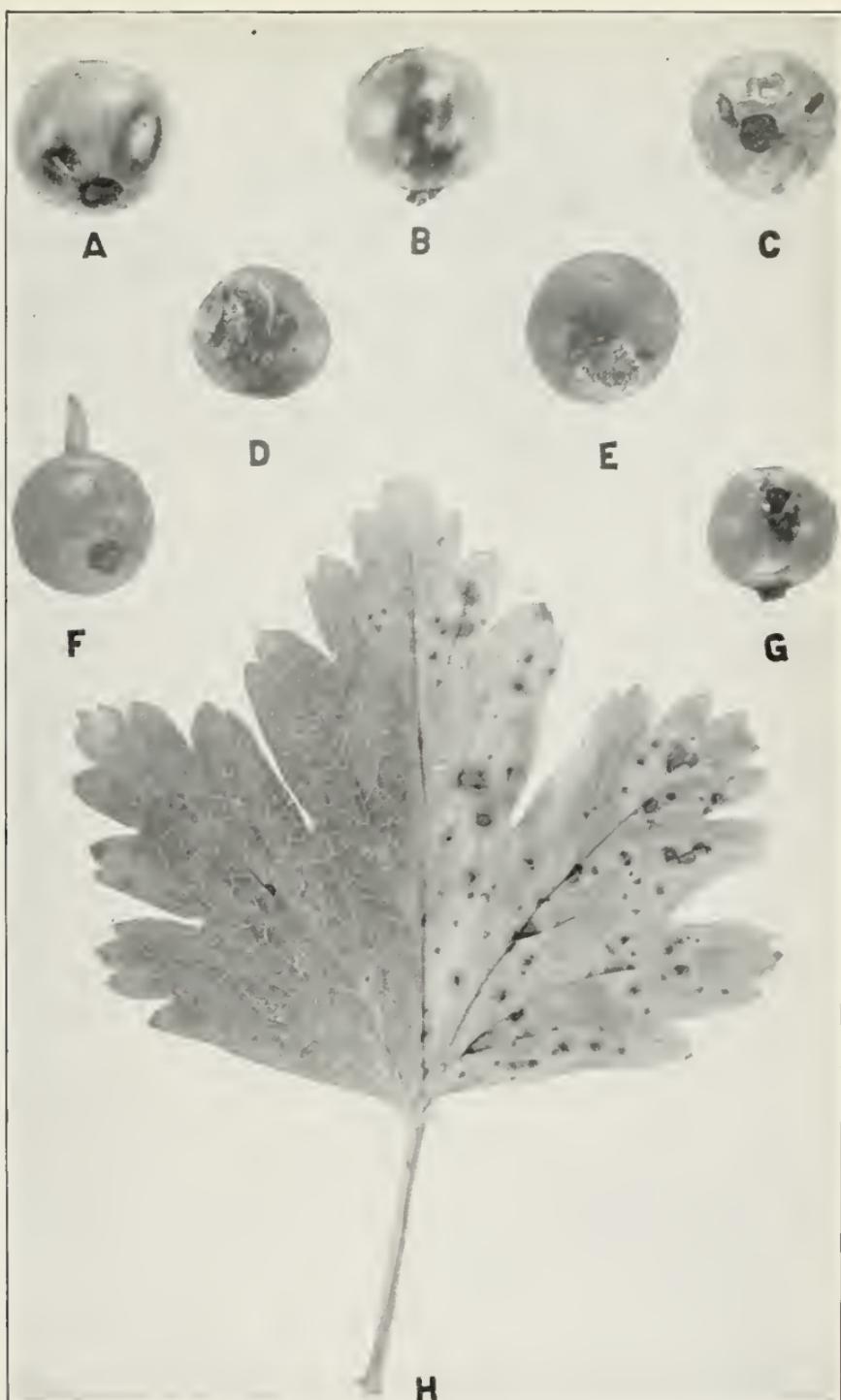


Figure 15.





A



B



C

Figure 16.





**A**

**B**

**C**



**D**

**E**



**F**

Figure 17.

